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# Studies on the formation of ascorbic acid (vitamin C) in plants

## 3. Relation between the accumulation of ascorbic acid and the carbohydrate contents in plants

By Tomota SUGAWARA

With 4 text-figures and 10 tables

(Received September 26, 1940)

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### I. Introduction

During recent years, a number of physiological and biochemical studies on the ascorbic acid contents of plants have been carried out. An investigation(39)<sup>(1)</sup> on the etiolated seedlings of cowpea plants proved that the amount of ascorbic acid increases, when additional carbohydrate

(1) Figures enclosed within brackets refer to the No. of literature cited at the end of this paper.



is supplied to them in the form of glucose. Similar relation, such as a correlation between the amount of ascorbic acid and glucose content in leaves were found by MOLDTMANN (30) in some monocotyledonous plants. In the previous papers (45, 46), the author has reported the fact that the formation of ascorbic acid in leaves of some seedlings is remarkably affected by the action of light, and when seedlings containing chlorophyll are exposed to light, the production of ascorbic acid takes place in the leaves. Moreover, he stated that the formation of ascorbic acid and the photosynthetic activity stand in a close physiological interrelationship.

Since the hexose may be regarded as the first stable product of photosynthesis, it will be very interesting to ascertain, whether the carbohydrate will play by itself an active part on the formation of ascorbic acid or not. On the other hand, not only has it been generally assumed, but also there has been some experimental evidence (38) that the hexose, such as glucose, can be converted into ascorbic acid by the seedlings during the process of germination. The present paper deals with the results of investigation, which, as the author hopes, may elucidate such relation to a certain extent.

## II. Materials and methods

1. *Materials.* Thirty species of plants used in these experiments are as follows: *Allium cepa* L., *Amorphophalus Konjac* KOCH, *Bletilla striata* REICH. fil., *Brassica pekinensis* RUPR., *Capsicum annuum* L., var. *acuminatum* FINGERH., *Colchicum autumnale* L., *Epipactis Thunbergii* A. GRAY, *Fagopyrum esculentum* MOENCH, *Glycine Max* MERR., *Helianthus annuus* L., *H. tuberosus* L., *Hosta Sieboldiana* ENGL., *Hyacinthus orientalis* L., *Iris gracilipes* A. GRAY, *I. tectorum* MAXIM., *Lilium Maximowiczii* REGEL, *Lycopersicum esculentum* MILL., *L. pimpinellifolium*, *L. pervianum*, *Mentha piperita* L., *Narcissus tazetta* L. var. *chinensis* ROEM., *Oryza sativa* L., *Physalis Alkekengi* L., *Phytolacca acinosa* ROXB., *Polygonatum falcatum* A. GRAY, *Raphanus sativus* L., *Solanum nigrum* L., *S. tuberosum* L., *Tulipa clusiana* DL., and *Zea Mays* L. Most of them were collected in the field of the University in Tokyo.

2. *Chemical analysis.* The amount of ascorbic acid is determined by the titration method of TILLMANS and HIRSCH, as modified by BESSEY and KING, TRESSLER, and FUJITA et al. (1, 13, 14, 27, 47). Twice normal sulfuric acid and 3 per cent metaphosphoric acid were used in the extraction of the plant tissue. The method is essentially the quantitative reduction of the dye indicator, 2,6-dichlorophenol-indophenol, by the ascorbic acid. The concentration of dye solution was previously determined by means of the amount of pure ascorbic acid which had been standardized by the use of iodine and standard thiosulfate solution. A sample of 10 grams plant tissue was quickly crushed in a mortar with



quartz sand and acid mixture (3 per cent metaphosphoric acid and 2-N sulfuric acid). After centrifuging for 15 minutes at about 1500 r.p.m., the extract was decanted and made up to 100–500 ccm with acid mixture. The amount of ascorbic acid in the extract was determined by the standardized indicator solution from a microburette.

Since an oxidized, but still physiologically active form of ascorbic acid, which is generally called dehydroascorbic acid, is present sometimes in plant tissues, the samples were treated with hydrogen sulfide for 15 minutes after the extraction, in order to reduce any oxidized ascorbic acid which might be yet present. This was followed by an one-hour scrubbing with carbon dioxide to remove hydrogen sulfide, and the titration was repeated with 2,6-dichlorophenol-indophenol solution.

The chlorophyll was measured by the colorimetric method (18,42). A sample of 10 grams was ground with a little amount of sodium carbonate and quartz sand, until the tissue is reduced to fine pulp, and then acetone is added to the mixture. Then the whole was introduced into a BUCHNER funnel and filtered. The extract was transferred to a separatory funnel, and ethyl ether was added. With the addition of distilled water to the ether-acetone mixture, two layers appeared and the bottom layer was run off. The ether extract was transferred to a stoppered bottle and to it were added 5 to 20 ccm saturated solution of KOH in methyl alcohol. The green layer of water-soluble saponified chlorophyll was run into a volumetric flask. The chlorophyll a plus b content of the green solution was determined by the colorimetric comparison with the inorganic color standard of GUTHRIE (18).

Reducing sugars and acid hydrolyzable carbohydrates in the samples were extracted according to the following procedure (25, 26). The tissue was extracted thrice with boiling 85 per cent alcohol. On cooling, a gelatinous precipitate appeared, the extracts were filtered into the original extract after having stood overnight. These aliquots were freed from alcohol by evaporating them almost to dryness in a water bath at 60°C. with a strong current of air. They were then taken up in hot distilled water and cooled after a few minutes by the addition of cold water. The solutions were cleared with neutral lead acetate and the excess of lead was precipitated with potassium oxalate. The reducing values of the cleared solutions were determined by the BERTRAND method, slightly modified. Acid hydrolyzable carbohydrates were obtained by the 2.5 per cent. hydrochloric acid inversion method and calculated from the reducing values by means of the sugar tables.

### III. Experimental results

#### 1. Relation between the accumulation of ascorbic acid and the reducing sugar content in plants

Etiolated seedlings 10 days old of rice and maize were used in these experiments. The results of the analysis for ascorbic acid and reducing

sugar are shown in table 1, in which the amount of each constituent is computed upon the dry weight basis. The data show the accumulation of both ascorbic acid and reducing sugar in the seedlings of various varieties of rice and maize at the same stage of their respective development. In the maize plant the ascorbic acid was found in the highest concentration

TABLE 1. Relation between the amounts of ascorbic acid and reducing sugar contents in etiolated seedlings in maize and rice in darkness.

Species	Varieties	Fresh weight		Dry weight	
		Ascorbic acid mg./g.	Reducing sugar %	Ascorbic acid mg./g.	Reducing sugar %
<i>Zea Mays</i> L.	Golden Bantam	0.627	0.56	6.607	5.89
	Hickory King	0.464	0.52	4.735	5.30
	Kôsyû	0.412	0.37	4.128	3.70
	Long Island Beauty	0.520	0.51	5.482	5.36
	Yellow Dent Corn	0.496	0.40	5.335	4.30
<i>Oryza sativa</i> L.	Hukubôzu	0.322	0.36	2.803	3.13
	Isigami-moti	0.346	0.28	3.149	2.54
	Kameno-o	0.346	0.40	2.771	3.20
	Rikuu No. 132	0.351	0.51	3.196	4.63

in Golden Bantam, which contained the highest amount of reducing sugar, and exactly similar results were also obtained in the rice seedlings. In the latter case the ascorbic acid content was particularly high in leaves marked by the high concentration of reducing sugar. Considerable variation, however, was found in different varieties, both in maize and rice, as regards the amount of ascorbic acid and sugar content. In all, the most outstanding feature of the results of the above experiments is the parallelism between the accumulation of ascorbic acid and the amount of reducing sugar in the plant tissues.

In some experiments with seedlings grown under natural conditions, in which plants older than previously used were tested, a close correlation was also found between the amount of ascorbic acid and that of reducing sugar content, although the height of the plants and the total quantity of their chlorophyll were very much greater, as compared to those of plants placed in darkness (table 2). So that, the synthesis of ascorbic acid in plant is dependent upon the presence of reducing sugar and may be formed if the photosynthesis occurs. The observation made in the above experiments leads us to the conclusion that the distribution of ascorbic acid tends to become parallel to that of reducing sugar.



TABLE 2. Relation between the amounts of ascorbic acid and reducing sugar contents in seedlings of maize and rice under natural conditions.

Species	Varieties	Fresh weight		Dry weight	
		Ascorbic acid mg./g.	Reducing sugar %	Ascorbic acid mg./g.	Reducing sugar %
<i>Zea Mays</i> L.	Hickory King	2.036	0.22	15.651	1.69
	Kôsyû	1.759	0.13	12.131	0.89
	Long Island Beauty	2.150	0.29	17.200	2.32
	Yellow Dent Corn	2.276	0.31	17.781	2.42
<i>Oryza sativa</i> L.	Isigami-moti	2.418	0.14	20.310	1.23
	Murasaki-ine	3.870	0.18	32.254	1.51
	Rikuu No. 132	2.276	0.13	19.780	1.20
	Sinriki	2.150	0.09	18.370	0.80

Another experiment was conducted in order to determine whether the above fact may be true for plants universally. The comparison was made concerning the amount of ascorbic acid, the concentration of chlorophyll and reducing sugar content in the leaves of several kinds of plants grown under natural conditions, for which cf. table 3.

A high percentage of ascorbic acid content was found in the genus *Iris*; thus, for example, *I. gracilipes* A. GRAY and *I. tectorum* MAXIM contained its 4.097 mg. and 3.268 mg. per gram respectively, whereas *Allium cepa* L. contained only 1.333 mg. per gram. A somewhat similar gradient was seen in respect to the reducing sugar contents. In most monocotyledonous and in some dicotyledonous plants there appears that in their leaves a close correlation exists between the accumulation of ascorbic acid and the quantity of reducing sugar or chlorophyll. The accumulation of ascorbic acid in plants, however, is not dependent upon the concentration of chlorophyll in plant tissues, as will be shown later. It might probably be formed from the hexose added to the nutrient medium in the absence of chlorophyll. From the observation above mentioned it may be concluded that the ascorbic acid distribution tends to be parallel to that of the reducing sugar in the monocotyledonous plants. In the most dicotyledonous plants, however, no such relation is found: their leaves may have a very small quantity of reducing sugars and yet high ascorbic acid content.

## 2. Amount of ascorbic acid and glucose, fructose, and mannose contents in leaves

The plants used in these experiments were *Amorphophalus Konjac* KOCH, *Helianthus annuus* L. and *H. tuberosus* grown in fields. At a

TABLE 3. The accumulation of ascorbic acid and reducing sugar or chlorophyll contents in leaves of various plants under natural condition.

Species	Stage of development	Date of sampling	Ascorbic acid mg./g.	Reducing sugar %	Chlorophyll mg./100g.
Monocotyledonous plants					
<i>Allium cepa</i> L.	Before flowering	28/4	1.333	0.08	83.1
<i>Amorphophalus Konjac</i> KOCH		1/7	1.842	0.17	—
<i>Belitilla striata</i> REICHB fil.	Flowering	23/4	1.855	0.15	118.3
<i>Colchicum autumnale</i> L.	After flowering	25/4	3.742	0.20	157.0
<i>Epipactis Thunbergii</i> A. GRAY	Beginning of flowering	28/4	2.246	0.16	—
<i>Hosta Sieboldiana</i> ENGL.	Before flowering	28/4	3.556	0.19	152.2
<i>Hyacinthus orientalis</i> L.	Flowering	28/4	2.371	0.18	124.4
<i>Iris gracilipes</i> A. GRAY	Before flowering	26/4	4.097	0.23	186.8
<i>I. tectorum</i> MAXIM	Before flowering	26/4	3.268	0.18	173.6
<i>Lilium Maximowiczii</i> REGEL.	Before flowering	27/4	1.940	0.10	—
<i>Narcissus tazetta</i> L. var. <i>chinensis</i> ROEM.	After flowering	28/4	3.048	0.18	146.0
<i>Oryza sativa</i> L.	25 days old seedling	8/6	2.150	0.12	120.2
<i>Polygonatum falcatum</i> A. GRAY	Flowering	24/4	2.371	0.15	—
<i>Tulipa chrsiana</i> DL.	Flowering	30/4	1.855	0.14	107.5
<i>Zea Mays</i> L.		1/7	1.759	0.13	118.6
Dicotyledonous plants					
<i>Brassica pekinensis</i> RUPR.		1/7	2.150	0.19	150.0
<i>Capsicum annuum</i> L. var. <i>acuminatum</i> FINGERH	Beginning of flowering	20/6	2.764	0.22	168.5
<i>Fagopyrum esculentum</i> MOENCH	Flowering	23/6	1.548	0.14	—
<i>Glycine Max</i> MERR.		1/7	2.418	0.39	172.6
<i>Helianthus annuus</i> L.	Before flowering	1/7	2.150	0.22	170.0
<i>H. tuberosus</i> L.	Before flowering	1/7	1.209	0.28	185.0
<i>Lycopersicum esculentum</i> MILL.	Beginning of flowering	10/6	1.382	0.17	153.4
<i>L. pimpinellifolium</i>		10/6	2.764	0.24	177.0
<i>L. peruvianum</i>		10/6	1.935	0.19	170.3
<i>Mentha piperita</i> L.		15/6	0.967	0.10	—
<i>Physalis Alkekengi</i> L.		20/6	1.382	0.11	165.5
<i>Phytolacca acinosa</i> ROXB.		20/6	4.837	0.29	195.8
<i>Raphanus sativus</i> L.	Bolting	1/7	1.759	0.18	—
<i>Solanum nigrum</i> L.		5/5	1.950	0.20	160.2
<i>S. tuberosum</i> L.		23/6	2.276	0.19	157.6

certain definite period the samples were taken and analyzed for ascorbic acid and sugars. The fructose and the mannose were determined by BOURQUELOT and HERISSEY, and NIJN methods (25) respectively. A comparison of the composition of the leaves is shown in table 4.



TABLE 4. The amounts of ascorbic acid and glucose, fructose and mannose contents in leaves of plants.

Species	Fresh weight					Dry weight				
	Ascorbic acid mg./g.	Reducing sugar %	Fructose %	Glucose %	Mannose %	Ascorbic acid mg./g.	Reducing sugar %	Fructose %	Glucose %	Mannose %
<i>Amorphophalus Konjac</i> KOCH	1.842	0.17	—	0.06	0.10	12.280	1.13	—	0.40	0.66
<i>Helianthus annuus</i> L.	2.150	0.22	—	0.20	—	16.538	1.69	—	1.53	—
<i>H. tuberosus</i> L.	1.209	0.23	0.11	0.14	—	7.556	1.75	0.68	0.87	—

The reducing sugar content in the leaves of Jerusalem artichoke is relatively higher than in the sunflower, but the glucose content is, on the contrary, lower. In the case of the Konjac, the amount of glucose is much less than in other plants, while that of mannose is much greater. The quantity of ascorbic acid in leaves is considerably high in sunflower and in Konjac which contain more glucose and glucose plus mannose respectively. On the other hand, the concentration of ascorbic acid in the Jerusalem artichoke was lower, and it contained more fructose. From these results, it seems, that there is no direct relation between the amount of reducing sugars and the accumulation of ascorbic acid. The Konjac contained little reducing sugars, and yet is exceptionally rich in ascorbic acid. On the other hand, Jerusalem artichoke known by its high concentration of reducing sugars produces less ascorbic acid.

### 3. Effect of sugars in the culture medium on the amount of ascorbic acid in seedlings

It has already been noted that the hexose such as glucose can be converted into ascorbic acid by the seedlings during the process of germination. About the chemical nature of the precursor of the latter comparatively little is known. The experiment was done to study the effect of sugars on the accumulation of ascorbic acid in various etiolated young plants under controlled environmental conditions described in the following lines. Maize seeds were germinated on moist quartz-sand, and seedlings were kept in darkness at 25°C. during five days. They were then transferred to a flask containing one per cent. sugar solutions or distilled water, under dark or light condition, and the solution was changed once a day. After five days culture in the solutions, the ascorbic acid content of the seedlings was determined, the results of which are given in table 5.

Synthesis of ascorbic acid may be effected by means of an external supply of sugar. The ascorbic acid will increase when the seedlings grown

TABLE 5. Effect of sugars in culture medium on the amounts of ascorbic acid of maize seedlings under darkness and light conditions. (mg./g.)

Conditions	Sugars	Reduced form of ascorbic acid	Dehydro- ascorbic acid	Total ascorbic acid
Darkness	Control (Distilled water)	0.406	0.056	0.462
	Fructose	0.552	0.063	0.615
	Glucose	0.546	0.083	0.629
	Maltose	0.485	0.075	0.560
	Mannose	0.532	0.080	0.612
	Sucrose	0.420	0.062	0.482
	Xylose	0.398	0.078	0.476
Light	Control (Distilled water)	0.627	0.176	0.803
	Fructose	0.668	0.181	0.849
	Glucose	0.715	0.174	0.889
	Maltose	0.665	0.195	0.860
	Mannose	0.700	0.175	0.875
	Sucrose	0.625	0.187	0.812
	Xylose	0.598	0.202	0.800

in dark or light are supplied with soluble carbohydrates such as glucose and fructose. On the contrary, an abundance of xylose prevents ascorbic acid formation, but the sucrose does not interfere with it, and this fact is most distinctly seen under the dark condition. A high concentration of ascorbic acid per unit weight of leaves was found, in fact, in the seedlings grown under the light condition. From the results above mentioned it will be seen that the concentration of available carbohydrates was considerably high in the leaves of etiolated seedlings but apparently was not high enough to provide for any apparent increase of total ascorbic acid.

In some experiment, young stems which have grown from storage roots of potato, Jerusalem artichoke and Konjac were used as materials. The tubers were placed in quartz sand in the dark and watered daily with tap water. The young shoots which have grown out from the tubers were cut into pieces about 15 to 20 cm. long, and they were carefully selected out for the uniformity of size. Then the plants were placed in a flask containing soluble carbohydrates. The data (table 6) which were obtained in the determination of ascorbic acid show that there was a definite increase of ascorbic acid by the addition of the soluble carbohydrate. It will be noticeable that there is a considerable variation of the ascorbic acid contents according to different kinds of sugars in the case of maize seedlings. This may, of course, be due in part to the fact of the characteristics of each sugar, because by the addition of some sugars, such as



TABLE 6. Effect of sugars in culture medium on the amounts of ascorbic acid of young plants (potato, Konjac and Jerusalem artichoke). (mg./g)

Species	Conditions	Sugars	Reduced form of ascorbic acid	Dehydro-ascorbic acid	Total ascorbic acid
<i>Solanum tuberosum</i> L.	Darkness	Control (Distilled water)	0.118	0.017	0.135
		Fructose	0.146	0.032	0.178
		Glucose	0.152	0.022	0.174
		Sucrose	0.124	0.026	0.150
	Light	Control (Distilled water)	0.185	0.052	0.237
		Fructose	0.219	0.011	0.230
		Glucose	0.237	0.057	0.294
		Sucrose	0.208	0.035	0.243
<i>Amorphophalus Konjac</i> KOCH	Light	Control (Distilled water)	0.336	0.194	0.530
		Fructose	0.351	0.274	0.625
		Glucose	0.510	0.357	0.867
		Maltose	0.430	0.222	0.652
		Mannose	0.620	0.365	0.985
		Sucrose	0.340	0.276	0.616
		Xylose	0.325	0.100	0.425
<i>Helianthus tuberosus</i> L.	Light	Control (Distilled water)	0.288	0.031	0.319
		Fructose	0.319	0.066	0.385
		Glucose	0.319	0.037	0.356
		Maltose	0.302	0.028	0.330

xylose it is almost impossible to increase the ascorbic acid content. The addition of hexose has led to the highest content of ascorbic acid, and that of disaccharides, such as sucrose and maltose, also to moderately high content, but in such cases it will be not be impossible that ascorbic acid was not derived directly from the sugars themselves, but from the products of their enzymic hydrolysis.

#### 4. Influence of girdling on the concentration of ascorbic acid in plants

The girdling experiment was done, inasmuch as it should cause an accumulation of reserve food products in the shoot. The plants used as materials were potatoes planted in field on April 1st. On April 20th, slanting incisions were made across the stem at five cm. from the ground. One half of the materials was thus treated, the other from the same group remaining intact as the control. To determine what effect the girdling

will cause upon reserve carbohydrates and ascorbic acid contained in the plants, the stems were cut out for analysis on May 21st.

The results of analysis are given in table 7, which clearly shows that the girdled plants contain about 2.5 per cent. less moisture and slightly more reducing sugars, acid hydrolyzable carbohydrates and ascorbic acid, than in the control. On the other hand, these results indicate that when the potato plants are girdled, the development of tubers is very poor. It

TABLE 7. Influence of girdling on the concentration of ascorbic acid, reducing sugars and acid hydrolyzable carbohydrates in leaves of potato-plants.

	Plants	Ascorbic acid mg./g.	Reducing sugar %	Acid hydrolyzable carbohydrates %
Fresh weight	Non-treated plant	2.150	0.17	0.65
	Treated plant	2.964	0.23	0.89
Dry weight	Non-treated plant	19.545	1.54	5.90
	Treated plant	21.760	1.69	6.54

may therefore be considered that a certain amount of carbohydrates which ordinarily are translocated into the tubers have accumulated in the shoots on account of the imperfect growth of the former. From these results of experiment, it will be seen that ascorbic acid is found also in high concentration in the plants which contain high amount of photosynthetic products.

##### 5. Relation between the photosynthetic activity and the accumulation of ascorbic acid in leaves

*Helianthus tuberosus* L., *Fagopyrum esculentum* MOENCH, *Lycopersicum esculentum* MILL., and *Solanum tuberosum*, which have grown on field were used as materials in our experiments. The method for measuring the apparent rate of photosynthesis is based on the determination of the quantity of organic substances formed or the dry matter accumulated per unit area of leaf during a certain definite period. This method consists in the comparison of the total quantity of acid hydrolyzable carbohydrates at different periods of one day. For this purpose, a leaf punch was used to cut discs from at least 50 leaves for determining the accumulation of dry matter per unit area of leaf. On the other hand, at a certain specific time, entire leaves were cut off and analyzed for ascorbic acid.

The data are given in table 8, which correspond somewhat to the typical case. The hourly variation of ascorbic acid contained in the leaves depends upon the photosynthesis which may be influenced by light, tem-



TABLE 8. Relation between the apparent photosynthetic activity and accumulation of ascorbic acid in leaves of plants.

	Plants	Hours					
		5 a.m.	8 a.m.	11 a.m.	2 p.m.	5 p.m.	8 p.m.
Dry weight of M <sup>2</sup> leaf area (g.)	Potato	45.54	46.56	48.36	51.72	52.62	51.98
	Jerusalem artichoke	47.00	48.24	49.54	54.16	55.02	52.96
Total acid hydrolyzable carbohydrates (as glucose) per M <sup>2</sup> leaf area	Potato	3.50	3.88	4.40	5.74	6.00	4.78
	Jerusalem artichoke	2.96	3.50	4.26	6.10	6.32	4.80
Ascorbic acid contents (mg./g.)	Potato	1.433	1.759	2.124	2.276	2.276	2.150
	Jerusalem artichoke	0.923	1.018	1.333	1.448	1.512	1.372
	Black wheat	2.276	2.418	2.580	2.764	2.680	2.447
	Tomato	0.967	1.248	1.536	1.548	1.433	1.205

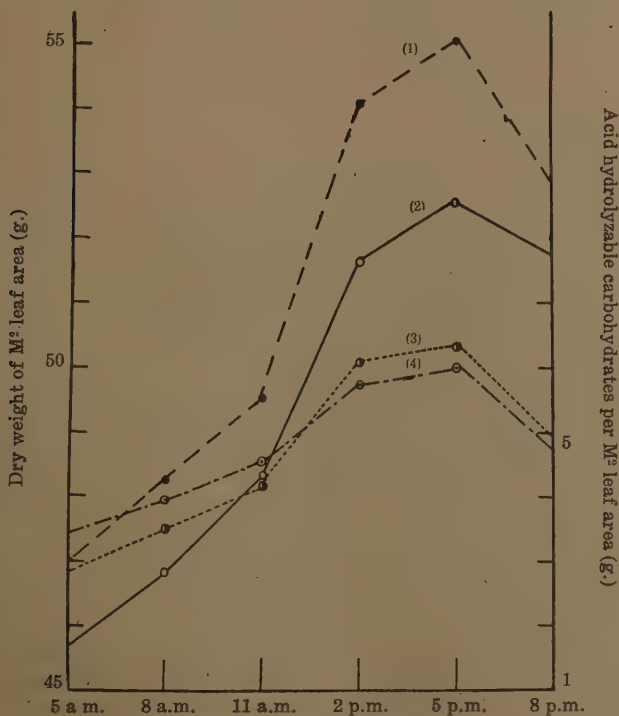


Fig. 1. Apparent photosynthesis of plants.

(1)—Artichoke—dry weight. (2)—Potato—dry weight. (3)—Artichoke—acid hydrolyzable carbohydrates. (4)—Potato—acid hydrolyzable carbohydrates.

perature, humidity, and other factors. The fact, that in the day time the increase of ascorbic acid was greater than in the morning or the evening in which the experiments have begun or ended respectively, suggests that the highest concentration of ascorbic acid in the plants occurs afternoon, i.e. in the case of the greatest photosynthetic activity (Fig. 1-2). The amount of ascorbic acid in Jerusalem artichoke bears the same

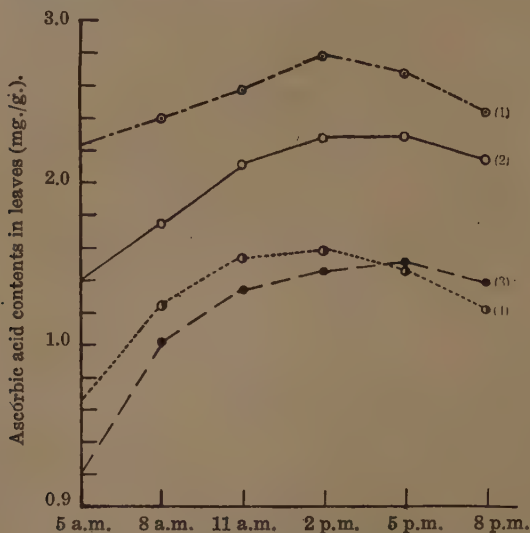


Fig. 2. Hourly change of ascorbic acid contents.  
(1)—Back wheat. (2)—Potato. (3)—Jerusalem artichoke. (4)—Tomato.

relationship to that of potato during the first three hours of the experiment. Since then, in artichoke its relatively less amount was formed in every hour, while the apparent photosynthesis during 12 hours was about 10 per cent above the average. It is of interest to note that both plants frequently showed the greatest assimilation and highest concentration

TABLE 9. Hourly solar radiation received on a horizontal surface and temperature (in average).

	Hours														Total
	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	6-7	
Gm.-cal./cm <sup>2</sup>	9.2	23.4	44.2	53.6	58.6	79.3	85.4	89.4	84.3	74.3	60.2	39.1	20.0	4.0	725.0
Temperature (Degree C.)	22.5	26.0	27.2	27.2	27.5	27.7	28.0	28.5	28.0	27.4	27.0	25.5	25.0	23.0	

of ascorbic acid between 11 a.m. and 2 p.m. This seems to be associated mainly with light conditions, although the influence of other factors might not be entirely excluded. It may also be seen that the meteorological conditions when these experiments were carried out, were favourable for the assimilation of carbon dioxide in the plants (Table 9).

It is clear from the above results that the ascorbic acid content of leaves was particularly high in the cases of high photosynthetic activity, and the close correlation was found between the amount of ascorbic acid and apparent photosynthesis in both plants.

On the other hand, another experiment was done with etiolated seedlings of maize plants under artificial light. Seeds were carefully selected for uniformity of their size, and they were germinated on moist quartz-sand. Seedlings which were cultivated in sand containing the nutrient

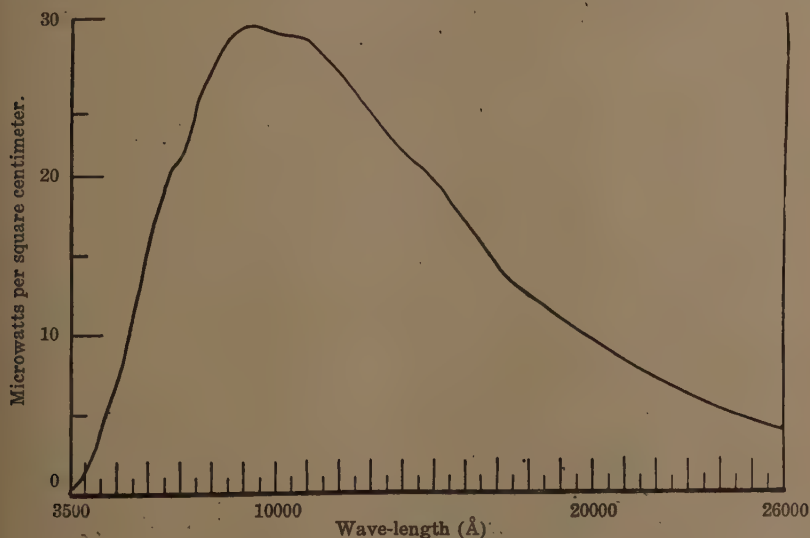


Fig. 3. Spectral radiant intensities of the lamp.

solution in the dark room at about 27°C. for five days were exposed to light. Leaves of etiolated seedlings on one hand and those of the latter 1-3 hrs. after the beginning of illumination on the other were analyzed for acid hydrolyzable carbohydrate and ascorbic acid, and the results were compared to each other (cf. table 10, where the data of analysis are given). The source of light used was a gas-filled lamp (1000 watt) of ordinary type, and the spectral radiant intensities of the lamp are given in figure 3.

It is shown in the table that with etiolated seedlings a considerable amount of light is necessary for the formation of ascorbic acid, and when



TABLE 10. Apparent photosynthesis and accumulation of ascorbic acid in maize seedlings.

	Hours									
	0	1	2	3	4	6	12	18	24	30
Acid hydrolyzable carbohydrate (g./100g.)	1.60	2.00	2.23	2.35	2.47	2.55	2.70	2.79	2.91	2.98
Ascorbic acid (mg./g.)	0.375	0.413	0.450	0.487	0.535	0.582	0.610	0.645	0.683	0.702

seedlings containing chlorophyll are exposed to light, ascorbic acid is accumulated in the leaves. Furthermore, the amount of ascorbic acid appears to increase until 30 hours after the beginning of illumination (end of experiment) when the quantity of carbohydrates reaches its maximum (Figure 4). If the carbohydrates are primary agents in the

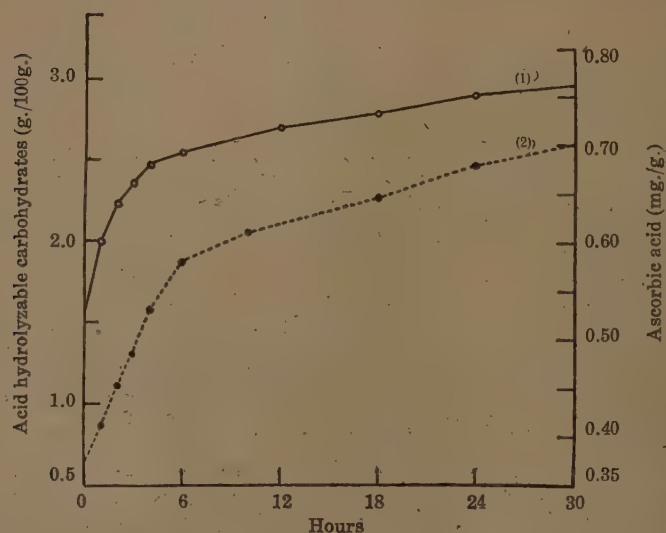


Fig. 4. Hourly change of acid hydrolyzable carbohydrates and ascorbic acid contents. (1)—Acid hydrolyzable carbohydrates. (2)—Ascorbic acid.

synthesis of ascorbic acids in the plants, there should be a fairly close correlation between the amount of these carbohydrates and the ascorbic acid produced. So that the total ascorbic acid content in the leaves of a plant should depend upon the concentration of carbohydrate per unit weight.

#### IV. Discussion and conclusion

Experiments described above lead us to the conclusion that there is a close relationship between the accumulation of ascorbic acid and the carbohydrate content in plants tested. Similar results were got by MOLDTMANN (30) on some monocotyledonous plants who stated that a correlation exists between the amount of ascorbic acid and glucose content. Basing on the results of such experiments, it was confirmed, that a general parallelism exists between the accumulation of ascorbic acid and the amount of simple sugars, and also there is a close correlation between the concentration of ascorbic acid and the quantity of chlorophyll in their leaves. BESSEY and KING(1) have already advanced the view that ascorbic acid acts, like many others, as oxido-reduction factor in correlation with the function of chlorophyll. According to CLARK (6), the distribution of ascorbic acid in the *Avena* coleoptile corresponds to that of chlorophyll in plants grown in the light, but does depend neither upon the presence of chlorophyll nor its distribution in the coleoptiles of plants grown in dark. In the previous experiments(45), the author found also that ascorbic acid increases in green leaves, while in albino seedlings there is no increase of ascorbic acid under illumination just as in the green seedlings kept in the dark during the same period. So that it will be seen that ascorbic acid is found in high concentration in those parts of plants which contain high amount of chlorophyll. The synthesis of ascorbic acid in the plants, however, is not dependent upon the presence of chlorophyll, as will be shown in future, but the acid may be formed if photosynthesis will occur. The ascorbic acid can probably be formed from the hexose added to the medium even in the absence of chlorophyll. Hence the occurrence of photosynthesis is not essential for the formation of ascorbic acid in the plants, but when chlorophyll is present, it is distributed in the same way as chlorophyll itself, i.e., the acid is in high concentration in leaves.

According to the microchemical observation of STRAKOSCH(40), the simple sugars alone appear in the mesophyll cells, and this fact seems to point decidedly in favor of the view that regards simple sugars and not sucrose as the primary sugar of photosynthesis. It may be however possible that both the pentoses and hexoses are among the first formed sugars. MILLET (29) in studying the photosynthesis in sorghum and corn, showed that although sucrose may be more abundant than the reducing sugar, this fact in itself is no argument for favoring the view regarding sucrose as the first sugar of synthetic production. A somewhat unusual concept in respect to the rôle of sucrose is that offered by PRIESTLEY(34), who holds that it is not concerned with photosynthesis at all, but that it is found as a by-product of the aging protoplasm of cells,

and as these cells become vacuolated sucrose is released. Using the data of DAVIS, DAISH, and SAWYER(8), he demonstrated that in reality the reducing sugars might be regarded as first sugars formed. Similar results have thereafter been got by CLEMENTS(7), who has used the sunflower, potato and soy bean, and found that the sucrose is apparently not the first sugar formed by leaves and only the simple sugars (hexose and pentose) seem to be first ones synthesized by plants. In our present experiments, the results show that there is a close relationship between the accumulation of ascorbic acid and the amount of reducing sugars, because the decrease of the accumulation of ascorbic acid is associated with that of reducing sugar content. The connection of photosynthetic product such as hexose and ascorbic acid was ascertained by the results of these experiments: the direct relationship between ascorbic acid and the photosynthetic products may be inferred from the fact that the accumulation of ascorbic acid contents in leaves increases when the photosynthesis occurs.

Though the investigation of the chemical nature of the precursor will be of great interest, comparatively little is known about it. It has been generally assumed and there has been some experimental evidence to show that a hexose such as glucose can be converted into ascorbic acid by the seedlings during the process of germination. Recently, REID(39) studied the behaviour of etiolated cowpea seedlings under darkness and has found that ascorbic acid increases in them when additional carbohydrate in the form of glucose was supplied to them. The investigation proves that a considerable amount of ascorbic acid was found in seedlings which were cultured on the medium containing sugar, and among six kinds of sugars examined, glucose, fructose and mannose gave the highest content of ascorbic acid, though slight variation was observed according to different species of plants. Disaccharides such as sucrose and maltose also gave moderately high content, but it might be possible that ascorbic acid is not derived from the disaccharides themselves but from the products of their enzymic hydrolysis. Xylose either gave very low or absolutely negative value in this respect.

In all, it may certainly be concluded that the ascorbic acid is synthesized from photosynthetic products such as hexose in plants.

## V. Summary

(1) Experiments were done for studying the accumulation of ascorbic acid concerning some species of plants grown under artificial and natural environmental conditions.

(2) A partial parallelism was found between the amount of ascorbic acid and the reducing sugar content in rice and maize seedlings grown



both in light and in darkness. Similar fact was observed in some other species of plants.

(3) An increase in ascorbic acid content of the plants was found in seedlings which were cultured on sugar medium. Of six kinds of sugars examined, glucose, fructose, and mannose lead to the highest content of ascorbic acid, then follow sucrose and maltose in this respect; xylose gives either very low or absolutely negative value of ascorbic acid content.

(4) In the girdled plants which have slightly more reducing sugars and acid hydrolyzable carbohydrates than the non-girdled ones, an increase in ascorbic acid content of the leaves was observed.

(5) The ascorbic acid content of leaves was particularly high under the high activity of photosynthesis, and the close correlation was found between the amount of ascorbic acid and the intensity of apparent photosynthesis.

(6) A direct relationship between the accumulation of ascorbic acid and photosynthetic products such as hexose is supposed to exist.

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## VI. Literature cited

- 1) BESSEY, O. A. and KING, C. G.: The distribution of vitamin C in plant and animal tissue and its determination. *Biol. Chem.* **103**: 687, 1933.
- 2) BISWAS, H. G. and DAS, K. L.: A comparative study of vitamin C in a few germinated oil seeds. *Science and Culture* **3**: 176, 1937. (*Chem. Abstr.* **218**, 1938).
- 3) BOGART, R. and HUGHES, J. S.: Ascorbic acid (vitamin C) in sprouted oats. *Jour. Nat.* **10**: 157, 1935.
- 4) BONNER, J. and BONNER, D.: Ascorbic acid and the growth of plant embryos. *Proc. Nat. Acad. Sci.* **24**: 70, 1938.
- 5) CHICK, H. and DELF, E. M.: The antiscorbutic value of dry and germinated seeds. *Biochem. J.* **13**: 199, 1919.
- 6) CLARK, W. G.: Ascorbic acid in the *Avena* coleoptile. *Bot. Gaz.* **99**: 116, 1937.
- 7) CLEMENTS, H. F.: Hourly variations in carbohydrate content of leaves and petioles. *Bot. Gaz.* **89**: 241, 1930.
- 8) DAVIS, W. A., DAISH, A. J. and SAWYER, G. C.: Studies of the formation and translocation of carbohydrates in plants. 1. The carbohydrates of the mangold leaf. *Jour. Agric. Sci.* **7**: 255, 1916.

- 9) DAVIS, W. A. and SAWYER, G. C.: Studies of the formation and translocation of carbohydrates in plants. III. The carbohydrates of the leaf and leaf stalks of the potato. The mechanism of the degradation of starch in the leaf. *Jour. Agric. Sci.* **7**: 352, 1916.
- 10) DAVIES, W., ATKINS, G. A. and HUDSON, P. C. B.: The effect of ascorbic acid and certain indole-derivatives on the regeneration and germination of plants. *Ann. Bot. N. S.* **1**: 329, 1937.
- 11) EMMERIE, A. and VON EEKELEN, M.: The chemical determination of vitamin C with removal of interfering reducing and coloured substances. *Biochem. J.* **28**: 1153, 1934.
- 12) FELLERS, C. R.: The effect of processing on vitamins in fruits and vegetables. A review. *Massach. Agric. Exp. Sta. Bull.* **338**; 1936.
- 13) FUJITA, A. u. IWATAKE, D.: Über die Bestimmung von Vitamin C mittels 2,6-Dichlorphenol-indophenol. *Biochem. Z.* **277**: 293, 1935.
- 14) FUJITA, A. u. EBIHARA, T.: Kolorimetrische Bestimmung von Vitamin C mittels Phospho-18 Wolfram Säure I. Bestimmung von Gesamt- Vitamin C. *Biochem. Z.* **290**: 192, 1937.
- 15) FUJITA, A. u. EBIHARA, T.: Über die Verteilung des Vitamin C in tierischen und pflanzlichen Geweben I. *Biochem. Z.* **290**: 201, 1937.
- 16) GIROUD, A., RATSIMAMANGA, R. et LEBIOND, C. P.: Parallélisme entre la vitamine C et la chlorophylle. *Compt. Rend. Soc. Biol. Paris*, **117**: 612, 1934.
- 17) GIROUD, A. et RATSIMAMANGA, R.: Relations entre la vitamine C et les carotinoïdes. *Compt. Rend. Soc. Biol. Paris*, **118**: 874, 1934.
- 18) GUTHRIE, J. D.: A stable colorimetric standard for chlorophyll determinations. *Amer. Jour. Bot.* **15**: 86, 1928.
- 19) HAVAE, L.: Ascorbic acid (vitamin C) and the germination and growth of seedlings. *Nature*, Sept. 14, 435, 1935.
- 20) HELLER, V. G.: Vitamin synthesis in plants as affected by light source. *J. Biol. Chem.* **76**: 499, 1938.
- 21) HUSEN, SYNNOVE, v.: Effect of vitamin C (ascorbic acid) on the growth of plants. *Nature*, Sept. 28, 516, 1935.
- 22) IJDO, J. B. H.: Relation between soil condition and the carotene and vitamin C content of plants. *Acta brevia neerl. Physiol.* **5**: 167, 1935.
- 23) IJDO, J. B. H.: The influence of fertilizers on the carotene and vitamin C content of plants. *Biochem. Jour.* **30**: 2307, 1936.
- 24) KESSLER, W.: Über den Vitamin C-Gehalt deutscher Apfelsorten und seine Abhängigkeit von Herkunft, Lichtgenuss, Düngung, Dichte des Behanges und Lagerung. *Gartenbauwissenschaft.* **13**: 619, 1939.
- 25) KLEIN, G.: *Handbuch der Pflanzenanalyse.* 1932.
- 26) LOOMIS, W. E. and SHULL, C. A.: *Methods in plant physiology.* 1937.
- 27) MACK, G. L. and TRESSLER, D. K.: Vitamin C in vegetables. VI. A critical investigation of the TILLMANS method for the determination of ascorbic acid. *J. Biol. Chem.* **118**: 735, 1937.
- 28) MATSUOKA, T.: Studies on vitamin C. *Bull. Agr. Chem. Soc. Japan*, **12**: 1203, 1936.
- 29) MILLER, E. C.: Daily variation of the carbohydrates in the leaves of corn and sorghums. *Jour. Agric. Res.* **27**: 785, 1924.
- 30) MOLDTMANN, H. G.: Untersuchungen über den Ascorbinsäuregehalt der Pflanzen in seiner Abhängigkeit von inneren und äusseren Faktoren. *Planta* **30**: 20, 1939.

- 31) MURPHY, E.: Vitamin C and light. Proc. Amer. Soc. Hort. Sci. **36**: 498, 1938.
  - 32) NEUBAUER, M.: Das Vitamin C in der Pflanze. Protoplasma **33**: 345, 1939.
  - 33) PHILLIS, E. and MASON, T. G.: Studies on the transport of carbohydrates in the cotton plant. Ann. Bot. **47**: 585, 1933.
  - 34) PRIESTLEY, J. H.: The first sugar of photosynthesis and the rôle of cane sugar in the plant. New Phytol. **23**: 255, 1924.
  - 35) RAKSHIT, P. C.: Über den Einfluss des Chlorophylls auf die Autooxydation der Ascorbinsäure. Biochem. Z. **297**: 153, 1938.
  - 36) RANDOIN, L., GIROUD, A. et LEBLOND, C. P.: Relation entre le teneur en vitamin C de divers tissus végétaux et la présence ou l'absence de chlorophylle. Compt. Rend. Soc. Biol. Paris, **120**: 297, 1935.
  - 37) RANDOIN, L., GIROUD, A. et LEBLOND, C. P.: Recherches biologiques et biochimiques sur le teneur en acide ascorbique des tissus chlorophylliens et achlorophylliens. Bull. Soc. Chem. Biol. Paris, **17**: 1646, 1935.
  - 38) RAY, S. N.: The nature of the precursor of the vitamin C in the vegetable kingdom. Biochem. Jour. **28**: 996, 1934.
  - 39) REID, M. E.: The effect of light on the accumulation of ascorbic acid in young cowpea plants. Amer. Jour. Bot. **25**: 701, 1938.
  - 40) STRAKOSCH, S.: Ein Beitrag zur Kenntnis des Kohlenhydratstoffwechsels von *Beta vulgaris* (ZUCK). Sitzber. K. Akad. Wiss. Wien. **116**: 855, 1907.
  - 41) STROHECKER, R.: Über die Bildung, Entstehung und örtliche Vorkommen von Vitamin C in pflanzlichen Geweben. Zs. f. Unters. d. Lebensm. **70**: 76, 1935.
  - 42) SUGAWARA, T.: On the determination of chlorophyll (in Japanese). Agric. and Hort. **12**: 1875, 1937.
  - 43) SUGAWARA, T.: Influence of fertilizers on the ascorbic acid content of spinach. Jour. Soc. Soil and Manure, Japan, **12**: 567, 1938.
  - 44) SUGAWARA, T.: Studies on the ascorbic acid contents in the spinach. Jour. Hort. Assoc. Japan, **10**: 189, 1939.
  - 45) SUGAWARA, T.: Studies on the formation of ascorbic acids in plants. I. Influence of light on the ascorbic acid contents in various etiolated seedlings. Jap. Jour. Bot. **10**: 141, 1939.
  - 46) SUGAWARA, T.: Studies on the formation of ascorbic acid in plants. 2. The influence of radiation of different wave-lengths on the ascorbic acid contents in etiolated seedlings. Jap. Jour. Bot. **10**: 325, 1939.
  - 47) TILLMANS, J., HIRSCH, P. u. JACKISCH, J.: Das Reduktionsvermögen pflanzlicher Lebensmittel und seine Beziehung zur Vitamin C. Zs. f. Unters. d. Lebensm. **63**: 241, 1932.
  - 48) TONNTTI, E.: Ergebnisse histochemischer Vitamin C Untersuchungen. Sammelreferat. Protoplasma **31**: 147, 1938.
  - 49) VIRTANEN, A. J., HAUSEN, u. SAASTEMOINEN: Untersuchungen über die Vitaminbildung in Pflanzen. Biochem. Z. **267**: 179, 1933.
  - 50) WEBER, F.: Tüpfel-Reaktionen zur Orientierung über den Vitamin C-Gehalt von Pflanzen. Protoplasma **33**: 474, 1939.
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# Investigations on the photosynthesis of leaves in rice-plants

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With 7 text-figures and 16 tables

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Rice-plants were selected for the studies above indicated on account of their economic importance as the main crop in Japan. The experiments must be carried out under controlled environmental conditions in order to get a theoretical knowledge of photosynthetic activity, while, on the other hand, studies under natural conditions will give some informations about the practice of the cultivators. This paper presents a report of daily and seasonal changes of photosynthetic activity of rice-plant leaves under approximately natural as well as under controlled light conditions. A question, why a poor yield of rice occurs occasionally in the northern part of Japan in the case of insufficient radiation, might at least partially be solved by the results of the author's investigation.

## Materials and methods

The experiments were conducted with the leaves of paddy rice belonging to the following five varieties namely, "Rikuu No. 132", "Hasseki", "Seniti", "Husakusirazu" and "Sinriki". The materials were cultured in soil or in nutrient solution. WAGNER's pot containing 10 kg. soil mixed with ammonium sulphate (1.2 g. N), superphosphate (3 g.  $P_2O_5$ ) and potassium sulphate (1.5 g.  $K_2O$ ) besides layers of pebbles and sand at the bottom for the convenience of irrigation were used for soil culture, while for water culture the enamel pots filled with KASUGAI's solution were employed, the composition of which is given in Tab. 1. The culture solution was changed once per two or three days and was more and more concentrated during the course of plant growth. The  $P_H$  concentration of the solution was kept at 5.8 by the addition of HCl.

Among several methods for measuring the apparent rate of photosynthesis, the following four methods were adopted in this investigation: (1) the iodine reaction (2) the weight-area (3) the saccharification and

TABLE 1. The composition of KASUGAI's nutrient solution for water culture.

	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	CaO	MgO	Fe <sub>2</sub> O <sub>3</sub>
(NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	4-12 mg.	2-4 mg.	3-6 mg.	0.4-0.8 mg.	0.6-1.2 mg.	0.1-1 mg.
Na <sub>2</sub> HPO <sub>4</sub> ·12H <sub>2</sub> O						
KCl						
CaCl <sub>2</sub> ·6H <sub>2</sub> O						
MgCl <sub>2</sub> ·H <sub>2</sub> O						
FeCl <sub>3</sub>						

(4) the gas-stream method. The first two methods are based on the determination of organic substances formed or the dry matter accumulated per unit leaf area during a definite period with color reaction or weight measurement respectively, the third involves a comparison of total acid hydrolyzable carbohydrate at different period of each day, and the fourth depends upon the quantitative determination of carbon dioxide

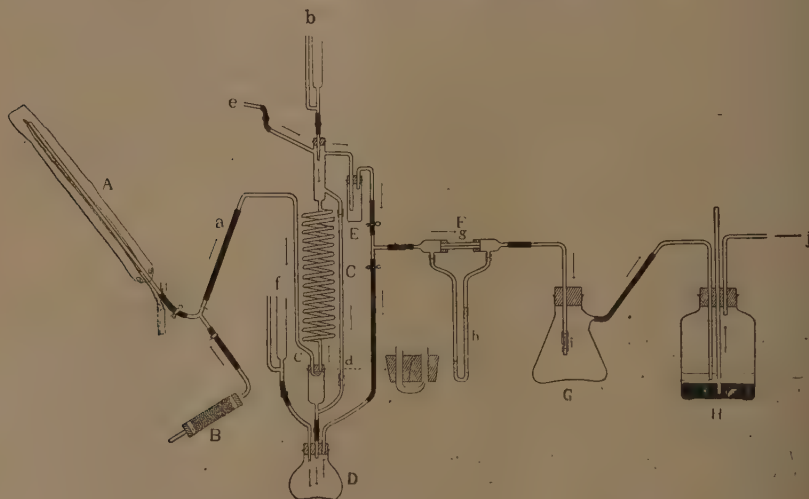


Fig. 1. Diagram of the apparatus for the gas-stream method.

absorbed by a known amount of leaf area. Each method has its own peculiarity.

The apparatus of the gas-stream method is essentially a modification of that described by BOYSEN-JENSEN (1928) and HEINICKE and HOFFMAN (1933 a), but a few modifications were made as shown in Fig. 1 (NOGUTI and SUGAWARA 1937).



The leaf chamber (A)<sup>(1)</sup>, which is the cellophane envelope, is slipped over a leaf of rice-plants, previously provided with a glass tube, which serves as its support and air route. The end of the tube must be kept from the cellophane a few millimeters away and then the corners of the envelope may be folded back at the base of blade to reduce the size of chamber to minimum. The supply of fresh air enters through the small opening which is left around the glass tube and the leaf. The air is drawn to the absorption unit after passing over the leaf. A long rubber tubing (a), as long as the materials which can be placed out door, connects the glass support and absorption unit. The tube B filled with soda lime is used to obtain air without carbon dioxide. The small end (c) of air intake glass tube, which is about 30 micra in diameter and serves to break the air stream into small bubbles, opens in the coiled reservoir, about 150 cm in length. The reservoir is connected directly to a burette containing alkali solution, and a definite amount of 1/10 N KOH solution is allowed to flow in it previously to the experiment. The side tube (d) serves to return the alkali solution which flows over with air, for removing carbon dioxide completely. A flask (D) is connected to the container of 1/10 N H<sub>2</sub>SO<sub>4</sub> (f) with a rubber stopper and is used for titration after a definite hour of operating the system. Bottle E is a regulator for overflowing solution; besides a certain reagent will indicate that carbon dioxide absorption is complete. The air passing through each unit is governed by a flowmeter (F) at a definite rate about two liters air per hour for each square centimeter of leaf surface. A thick glass capillary tube (g), 60 mm long, with a bore of less than 0.5 mm and arms containing water serve for regulation to constant rate. Bottle G is a PALLADIN's pressure regulator containing a BUNSEN valve (i) and it is used when more than two units are operated at one time. A 1/4 horse-power electric pump is used to pull the air through the system. Four units are compactly assembled and mounted on a common stand together as shown in Fig. 2.

During the experiment one of the units is used as control to determine the amount of carbon dioxide absorbed by an equal volume of normal air obtained from an envelope without leaf. Thymolphthalein is chosen as an indicator in titration, on account of the distinctness of its end point of reaction.

The Riken printing paper gives a clear print of leaf, the area of which is subsequently measured by comparison of its weight with that of a definite area of paper. To determine the rate of photosynthesis under the conditions of light deficiency, the frame having a glass plate 3 mm in thickness or covered with two layers of cotton clothes is used for reducing

(1) The temperature within the leaf chamber was reported to be slightly high above normal when exposed for a prolonged sunlight (MATTHAEI 1905), but no such difference was found in our apparatus.

the intensity of radiation. The arrangement is set always to cut off the materials from the full sunlight. The temperature and relative humidity

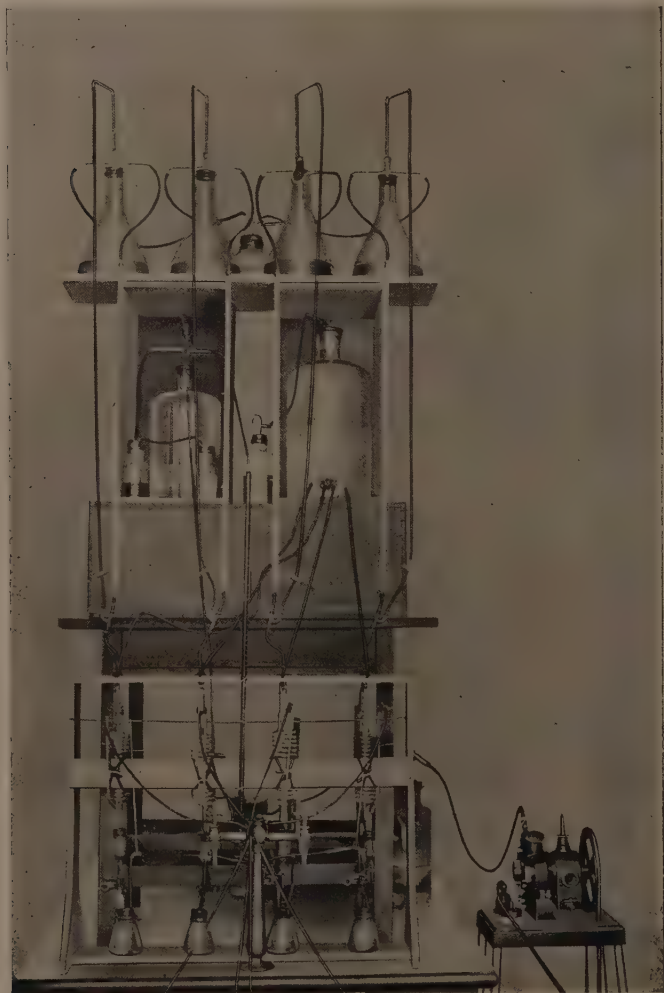


Fig. 2. An assembly of four absorption units used in the study of carbon dioxide assimilation.

in air during the experiments are recorded and the amount of light above ground is measured by the ROBIZT's bimetal actinograph.

## Experimental results

### 1. Daily change of assimilation under natural conditions

#### (1) *Experiments in 1936*

For following the daily course of photosynthesis which may be one of the characteristics in each species of plants under normal conditions, it will be necessary to get at first some general views of its type in rice-plants. The accumulation of starch in leaves was examined by means of the iodine test of SACHS on a certain number of samples in every two hours on July 20th. Starch was scarcely found early in the morning, and its amount, which gradually began to increase after 7 o'clock, reached the maximum in the first two hours of the afternoon, and then it decreased by and by.

The above observation shows us only the tendency of photosynthetic activity of the plants during a day under natural conditions, so that it was further studied quantitatively by measuring the increase of dry matter. On August 6th and 11th one half of each of ten leaves, which were selected in each of following varieties, "Hasseki", "Seniti" and "Husakusirazu", was cut off and at two hours intervals weighed after being dried in air. A slight varietal difference seems to be present, but

TABLE 2. Daily course of photosynthesis determined by the increase of dry weight.

Date		6 A.M.	8	10	Noon	2 P.M.	4	6
Aug. 6	Intensity of radiation <sup>(1)</sup>	0.391	0.558	0.647	1.116	1.088	0.893	0.056
	Temperature (C°)	29.0	30.0	31.5	31.5	32.0	32.0	31.0
	Relative humidity (%)	81.0	76.0	66.0	64.0	61.0	58.0	64.0
	Dry weight of the unit leaf area <sup>(2)</sup>	37.0	41.7	44.5	43.8	49.3	41.4	38.7
	Gain of dry weight per two hours		4.7	2.8	-0.7	5.5	-7.9	-2.7
Aug. 11	Intensity of radiation	0	0.234	0.937	0.513	0.815	0.234	0.056
	Temperature (C°)	28.0	30.0	29.5	31.0	31.5	31.0	29.5
	Relative humidity (%)	79.0	80.0	78.0	78.0	77.5	76.0	76.0
	Dry weight of the unit leaf area	36.3	39.0	42.7	42.9	39.3	41.3	37.7
	Gain of dry weight per two hours		2.7	3.7	0.2	-3.6	2.0	-3.6

(1) g. cal. on cm<sup>2</sup> per minute.

(2) g. per M<sup>2</sup>.



since a considerable variation, which may be due to the defect of experimental method, was observed in each measuring, all results were averaged, as will seen in Tab. 2 including the records of the meteorological conditions.

The type of apparent photosynthesis in these two days is somewhat different. On August 6th, the dry weight of unit leaf area increased almost regularly from the early morning, reached the maximum just after the noon, and then decreased rapidly. The same tendency was found in the morning on August 11th, but the dry weight changed irregularly afterwards, because the weather was cloudy in the afternoon in the latter case, while in the former it was extremely fine. Therefore, the type of photosynthesis, which was shown on August 6th, might be recognized as the normal one under good conditions.

To confirm this latter conclusion, the following four experiments were carried out successively between August 20th and September 11th. In the first case, the dry weight was examined every four hours on ten leaves of each variety on August 20th under a very fine weather and the weight of total ash was removed from it after burning the materials to obtain more accurate results. Just the same tendencies of photosynthesis were seen in all the varieties, as shown in Tab. 3.

TABLE 3. Daily course of photosynthesis determined by increasing dry weight.

Date			6 A.M.	10	2 P.M.	6
Aug. 20	Intensity of radiation <sup>(1)</sup>		0.167	1.116	1.294	0
	Temperature (C°)		23.0	26.0	27.5	26.0
	Relative humidity (%)		83.0	58.0	56.0	63.0
	var.	Dry weight minus ash in the unit leaf area <sup>(2)</sup>	30.3	33.3	34.0	32.4
	"Hasseki"	Gain of the weight per four hours		3.0	0.7	-1.6
	var.	Dry weight minus ash in the unit leaf area	26.4	30.6	35.2	31.5
	"Seniti"	Gain of the weight per four hours		4.2	4.6	-3.7
	var. "Husaku- sirazu"	Dry weight minus ash in the unit leaf area Gain of the weight per four hours	24.8	28.7	33.6	27.6
			3.9	4.9	-6.0	

(1) g. cal. on cm<sup>2</sup> per minute.

(2) g. per M<sup>2</sup>.

In the variety "Hasseki" the gain of weight was found to be slightly lower than that of others, but it may perhaps be a varietal characteristics caused by a remarkable difference of their growth rate: it will be discussed later concerning this fact.

TABLE 4. Daily course of photosynthesis determined by the saccharification method.

Date		6 A.M.		10		2 P.M.		5
Aug. 21	Intensity of radiation <sup>(1)</sup>		0		0.865		1.233	0
	Temperature (C°)		21.0		26.5		28.0	27.0
	Relative humidity (%)		81.0		63.0		43.0	52.0
	var. "Hasseki"	Weight of <i>d</i> -glucose <sup>(2)</sup> Gain of the weight per four hours	4.66		11.56		12.26	6.98
				6.9		0.7		-5.3
	var. "Seniti"	Weight of <i>d</i> -glucose Gain of the weight per four hours	5.90		12.51		14.58	7.22
				6.6		2.1		-7.4
	var. "Husaku- sirazu"	Weight of <i>d</i> -glucose Gain of the weight per four hours	6.44		11.22		13.00	7.59
				4.8		1.8		-5.4

(1) g. cal. on cm<sup>2</sup> per minute.(2) g. per m<sup>2</sup>.

TABLE 5. Daily change of photosynthesis determined by the weight-area method and by the saccharification method.

Date		6 A.M.		10		2 P.M.		6
Sept. 8	Intensity of radiation <sup>(1)</sup>		0		0.614		0.680	0.056
	Temperature (C°)		28.0		30.0		30.5	29.0
	Relative humidity (%)		80.0		70.0		65.0	77.0
	var.	Dry weight of the unit leaf area Gain of dry weight per four hours	40.54		42.74		43.43	41.38
				2.2		0.6		-1.6
	"Sinriki"	Weight of <i>d</i> -glucose <sup>(2)</sup> Gain of the weight per four hours	8.00		9.89		10.99	8.17
				1.87		1.1		-2.8
	Intensity of radiation <sup>(1)</sup>		0		0.700		0.781	0
	Temperature (C°)		28.0		30.0		30.0	29.0
Sept. 11	Relative humidity (%)		79.0		72.0		70.0	68.0
	var.	Dry weight of the unit leaf area Gain of dry weight per four hours	38.85		45.73		48.59	41.56
	"Sinriki"			6.9		2.9		-8.0

(1) g. cal. on cm<sup>2</sup> per minute.(2) g. per m<sup>2</sup>.

Then an experiment was done on August 21st, which was slightly cloudy. Using ten leaves of these three varieties, the activity of photosynthesis as measured in every four hours by the so-called saccharification method, in which starch-assimilate in leaves is converted into sugar by hydrolysis and determined quantitatively. The data obtained in the experiment (Tab. 4) coincide to each other among three varieties examined and may be reliable because of their agreement with the results of the previous one.

On September 8th and 11th, other two experiments were carried out with the plants of variety "Sinriki" according to the same plan as before and the results indicated in Tab. 5 were obtained.

The too small amount of assimilation product observed in the former case will attract attention and it might be due to the lack of radiation caused by the cloudiness.

## (2) *Experiments in 1937*

In these experiments the gas-stream method improved by the author is adopted and two varieties, the early ripening "Rikuu No. 132" and the late ripening "Husakusirazu", were used as materials to get some informations about the peculiarities of photosynthetic type due to the varietal difference.

In comparison with the results obtained in the previous experiments, the fact is immediately noticeable here that the intensity of radiation is most powerful among the factors which have influence on the type of photosynthesis, so that the data obtained in these experiments are treated separately according to the difference of radiation, i.e. fine or cloudy weather.

The photosynthetic activity marked by the amount of carbon dioxide absorbed by the leaf in every three hours was measured on a third leaf from the top thrice during July and August, and the results were as shown in Tab. 6.

Under fair weather in summer the intensity of radiation varies very regularly. It begins to increase rapidly at 6 o'clock A.M. and reaches the maximum about after three hours, i.e. just before or after the noon. Almost the same intensity continues until 4 o'clock P.M. and then it decreases gradually. The change of photosynthetic activity goes parallel to that of radiation, and the results agree nearly with those obtained in the previous year, except the following two points: the sudden rise of the intensity and the occurrence of maximum just before or after the noon in the early or late variety respectively (Fig. 3).



TABLE 6. Daily change of photosynthesis under fine weather determined by the gas-stream method (1).

Date		6 A.M.	9	Noon	3 P.M.	6
July 20	Intensity of radiation <sup>(1)</sup>	0.162	1.094	1.546	1.599	0.095
	Temperature (C°)	28.0	31.0	33.0	29.5	27.5
	Relative humidity (%)	93.0	61.5	59.0	68.0	70.5
	Carbon dioxide absorbed by unit leaf area per three hours <sup>(2)</sup>	var. "Rikuu No. 132"	5.81	12.91	9.87	7.56
		var. "Husaku-sirazu"	6.06	9.13	10.00	5.61
Aug. 2	Intensity of radiation	0.452	1.674	1.741	1.751	0.290
	Temperature (C°)	28.0	30.0	31.5	31.0	29.5
	Relative humidity (%)	62.0	68.0	68.5	70.0	75.5
	Carbon dioxide absorbed by unit leaf area per three hours	var. "Rikuu No. 132"	5.32	19.87	16.65	9.94
		var. "Husaku-sirazu"	6.24	15.03	15.88	9.36
Aug. 16	Intensity of radiation	0.240	1.674	1.674	1.384	0.128
	Temperature (C°)	32.0	32.0	32.0	32.5	30.0
	Relative humidity (%)	92.0	85.0	57.0	59.5	65.0
	Carbon dioxide absorbed by unit leaf area per three hours	var. "Rikuu No. 132"	4.41	14.37	12.16	5.53
		var. "Husaku-sirazu"	4.23	13.69	17.01	6.37

(1) g. cal. on  $\text{cm}^2$  per minute.(2) mg. per  $50 \text{ cm}^2$ .

An observation was, moreover, made with the late variety "Husaku-sirazu" in the middle of September. In that case, however, the intensity of radiation was not so great as in August in spite of fine weather, and consequently the type of photosynthesis was so confused, as the varietal difference has disappeared, as indicated in Tab. 7.

Under overcast sky not only is the quantity of solar radiation fallen on soil surface small, but also irregular in every moment, and the activity of photosynthesis is also variable corresponding to the weather conditions. Thrice during the summer, i.e. July 23rd, August 3rd and 30th, the rate of carbon dioxide assimilation was determined with a leaf of rice-plants.

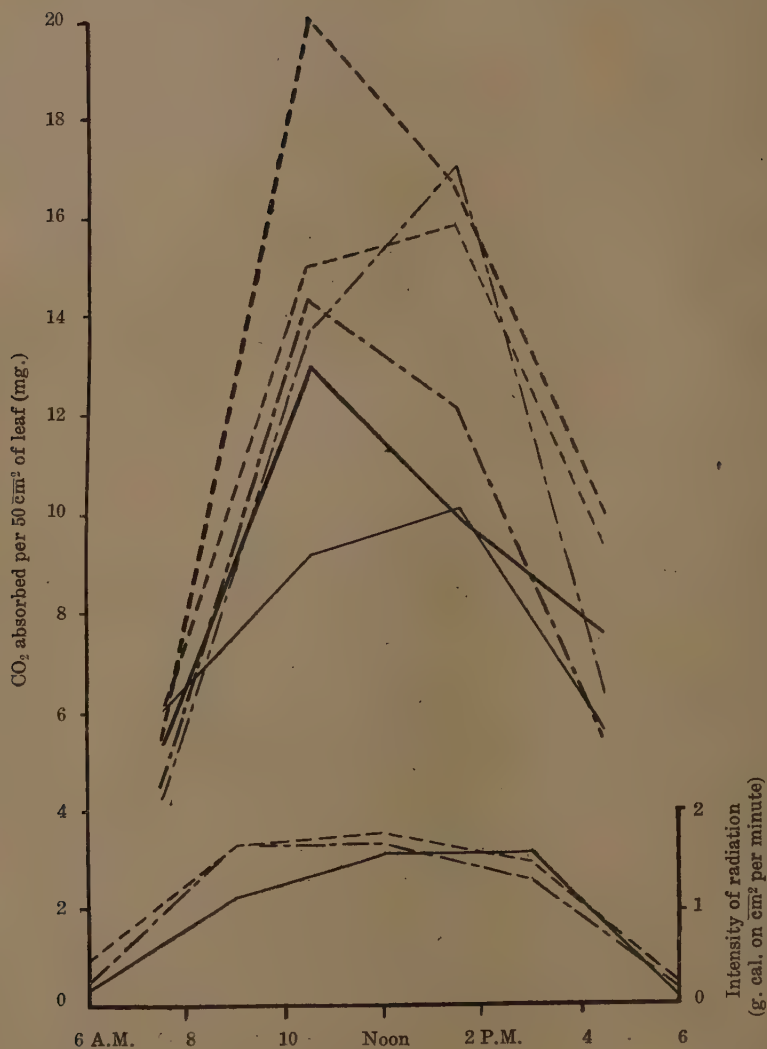


Fig. 3. Daily change of photosynthesis under fine weather.  
 — July 20, - - - Aug. 2, . . . Aug. 16, 1937; thick  
 line—"Rikuu No. 132", fine line—"Husakusirazu".

TABLE 7. Daily change of photosynthesis under fine weather determined by the gas-stream method (2).

Date	6 A.M.	9	Noon	3 P.M.	6
Intensity of radiation <sup>(1)</sup>	0.709	0.999	1.741	0.921	0.128
Temperature (C°)	19.0	21.0	24.0	24.0	23.0
Sept. 14 Relative humidity (%)	80.5	71.0	51.5	43.0	55.5
Carbon dioxide absorbed by unit leaf area per three hours <sup>(2)</sup>		5.55	14.58	8.02	6.25

(1) g. cal. on  $\text{cm}^2$  per minute.(2) mg. per  $50 \text{ cm}^2$ .

In the first case the measurement was carried out every three hours and in the two others every two hours to get more accuracy, because both the intensity of radiation and that of photosynthesis changed very frequently. The results obtained in these experiments are given in Tab. 8 and 9.

TABLE 8. Daily change of photosynthesis under cloudy weather determined by the gas-stream method (1).

Date	6 A.M.	9	Noon	3 P.M.	6
Intensity of radiation <sup>(1)</sup>	0	1.289	0.854	0.965	0.097
Temperature (C°)	27.0	33.5	29.5	30.5	27.5
Relative humidity (%)	91.0	82.5	82.0	68.0	81.0
July 23 Carbon dioxide absorbed by unit leaf area per three hours <sup>(2)</sup>	var. "Rikuu No. 132"	3.95	4.56	10.03	3.95
	var. "Husaku-sirazu"	4.09	6.01	9.63	5.49

(1) g. cal. on  $\text{cm}^2$  per minute:(2) mg. per  $50 \text{ cm}^2$ .

TABLE 9. Daily change of photosynthesis under cloudy weather measured by the gas-stream method (2).

Date		6 A.M.	8	10	Noon	2 P.M.	4	6
Aug. 3	Intensity of radiation <sup>(1)</sup>	0.580	1.451	0.999	1.289	0.870	1.076	0.223
	Temperature (C°)	28.0	29.0	30.0	31.0	31.5	31.0	29.5
	Relative humidity (%)	91.0	72.5	73.0	65.0	64.5	58.0	78.5
	Carbon di-oxide absorbed by unit leaf area per two hours <sup>(2)</sup>							
	var. "Rikuu No. 132"		4.49	6.92	8.99	13.84	6.92	5.00
Aug. 30	var. "Husakusirazu"		2.82	5.89	7.51	12.47	7.03	5.21
	Intensity of radiation	0.419	1.546	0.965	1.512	1.451	0.257	0.195
	Temperature (%)	28.5	30.0	31.0	32.0	32.5	31.0	30.0
	Relative humidity (%)	94.5	90.0	71.0	61.5	59.0	69.0	81.0
	Carbon di-oxide absorbed by unit leaf area per two hours							
	var. "Rikuu No. 132"		1.72	9.54	9.36	6.78	5.80	2.23
	var. "Husakusirazu"		1.69	11.79	12.44	11.83	8.24	2.48

(1) g. cal. on  $\text{cm}^2$  per minute.(2) mg. per  $50 \text{ cm}^2$ .

In the photosynthesis above indicated such a tendency was seen in general as that it is apt to occur all at once in the morning or in the afternoon, and therefore, the varietal difference has completely disappeared (Fig. 4).

### (3) Experiments in 1938

In addition to "Rikuu No. 132" and "Husakusirazu", "Seniti", one of the late ripening variety was also used as materials in these experiments, and the apparent photosynthesis was examined by the gas-stream method on July 29th and August 6th, just according to the same plan as in previous year. The climatic conditions were somewhat abnormal in July 29th, because the radiation was insufficient on account of the appearance of heavy clouds, while in August 6th it was quite normal on account of very fine weather. The results indicated in Tab. 10 proved to be identical completely to those above mentioned (Fig. 5 and 6).



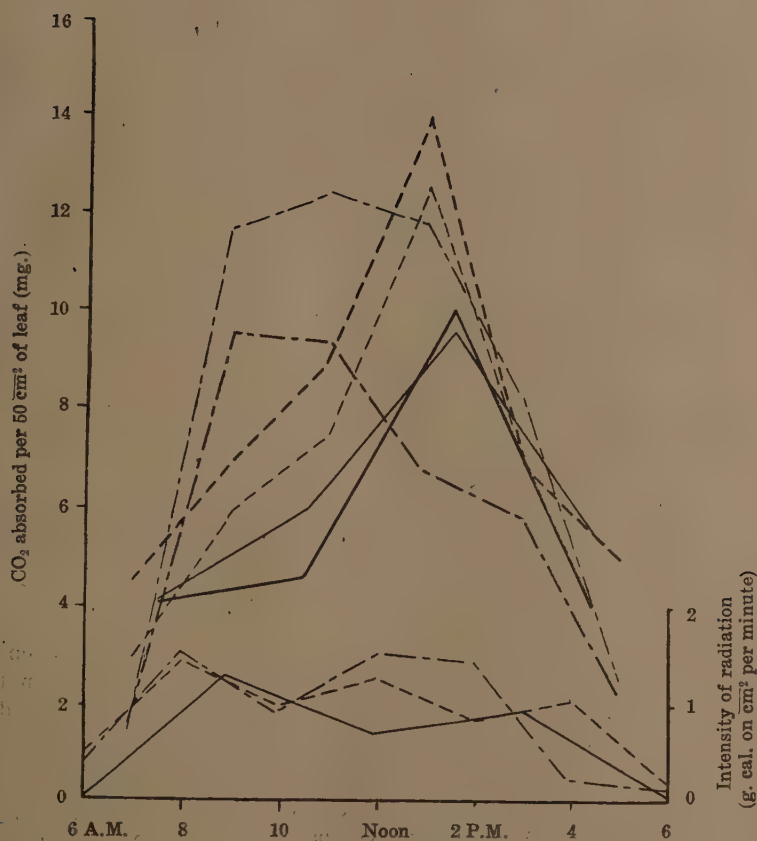


Fig. 4. Daily change of photosynthesis under cloudy weather.

July 23, ----- Aug. 3, ----- Aug. 30, 1937; thick line—"Rikuu No. 132", fine line—"Husakusirazu".

TABLE 10. Daily change of photosynthesis determined by the gas-stream method.

Date		6 A.M.	9	Noon	3 P.M.	6
July 29	Intensity of radiation <sup>(1)</sup>	0.140	0.279	0.558	0.502	0.045
	Temperature (C°)	28.5	33.0	30.0	30.0	29.5
	Relative humidity (%)	67.0	57.0	50.0	54.5	57.0
	Carbon dioxide absorbed by unit leaf area per three hours <sup>(2)</sup>					
	var. "Rikuu No. 132"	3.50	11.69	10.52	6.43	
	var. "Seniti"	3.86	10.17	9.24	4.51	
	var. "Husakusirazu"	3.35	8.68	8.01	4.68	
	Intensity of radiation	0.307	1.423	1.730	0.781	0.084
	Temperature (C°)	28.0	29.0	29.0	29.0	28.0
	Relative humidity (%)	61.0	55.0	49.0	49.0	55.0
Aug. 6	Carbon dioxide absorbed by unit leaf area per three hours					
	var. "Rikuu No. 132"	6.02	20.07	16.72	8.70	
	var. "Seniti"	6.13	14.32	18.84	9.79	
	var. "Husakusirazu"	6.04	16.31	16.92	9.07	

(1) g. cal. on cm<sup>2</sup> per minute.(2) mg. per 50 cm<sup>2</sup>.

## 2. Seasonal change of assimilation under natural conditions

It is generally said that the activity of photosynthesis is vigorous in the newly unfolded leaf. To prove this fact experimentally in rice-plants, an experiment was done with the variety "Husakusirazu" on September 12th, 1936, in the following way. The apparent photosynthesis denoted by the increase of dry matter was compared between ten top leaves, in which the tips of panicles were just emerging out on one hand, and the same number of the third leaves from the top on the other. A greater amount of synthetic products was formed in the young leaves as indicated in Tabl. 11.

The above results indicate that a healthy leaf borne on a definite position of stem must be used as material for the study on the seasonal change of photosynthesis. In the summer of 1937, the following experiments were carried out with two varieties of rice-plants; viz. the early variety "Rikuu No. 132" and the late variety "Husakusirazu". Once two

TABLE 11. Comparison of photosynthetic activity in the leaves in different growing stage.

Date		8 A.M.		Noon		2 P.M.		6
Sept. 12 (1936)	Intensity of radiation <sup>(1)</sup>	0.391		0.725		0.586		0
	Temperature (C°)	28.0		29.0		29.5		29.0
	Relative humidity (%)	78.0		73.0		58.0		69.0
	Top leaves							
	Dry weight of the unit leaf area <sup>(2)</sup>	38.11		46.38		46.97		43.91
	Gain of dry weight		8.27		0.59		-3.06	
	Third leaves							
	Dry weight of the unit leaf area	43.79		49.96		50.48		39.54
	Gain of dry weight		6.17		0.52		-10.94	

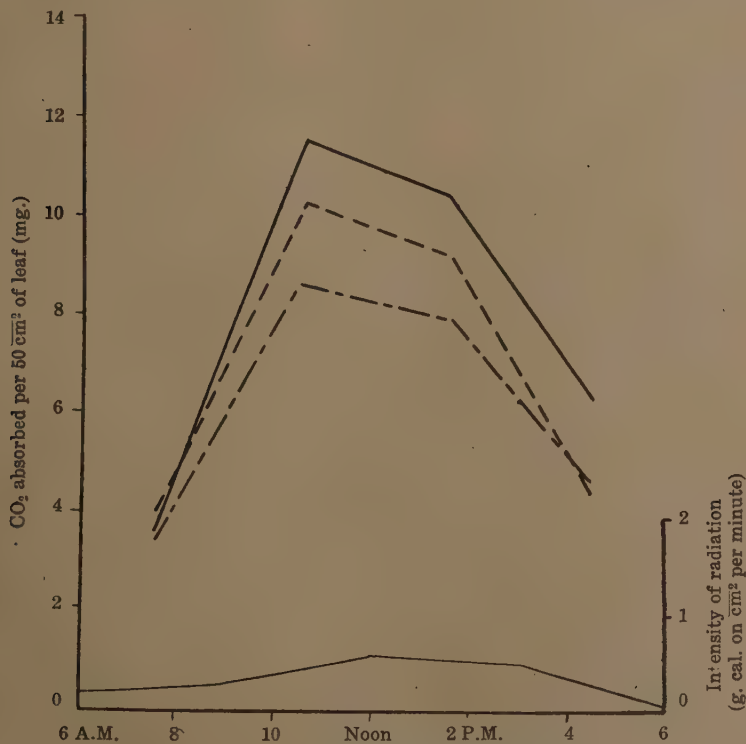
(1) g. cal. on  $\text{cm}^2$  per minute.(2) g. per  $\text{M}^2$ .

Fig. 5. Daily change of photosynthesis under cloudy weather.  
 July 29, 1938. — "Rikuu No. 132", - - - "Seniti",  
 - · - · - "Husakusirazu".

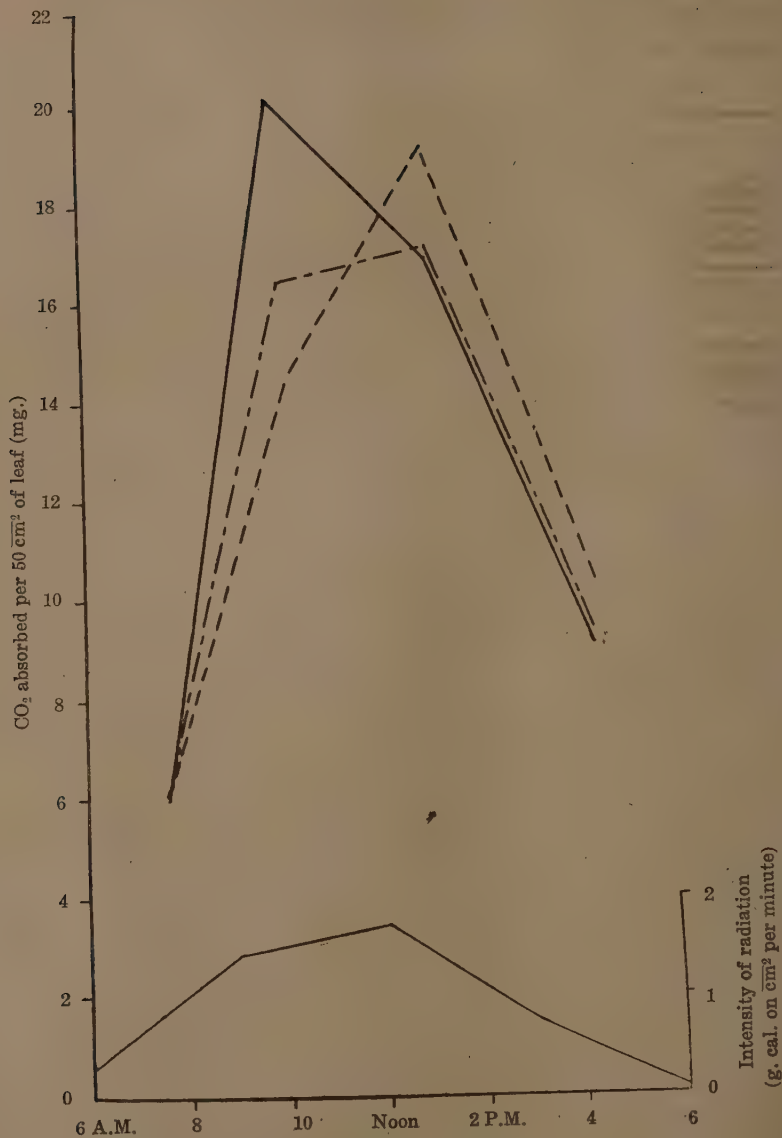


Fig. 6. Daily change of photosynthesis under fine weather.  
 Aug. 6, 1938. — "Rikuu No. 132", - - - "Seniti",  
 . . . "Husakusirazu".



weeks, the amounts of carbon dioxide absorbed during twelve hours after 6 o'clock A.M. were determined by the gas-stream method under fine weather and the results in Tab. 12 were obtained.

TABLE 12. Seasonal change of photosynthesis under natural conditions.

	Varieties	July 20	Aug. 2	Aug. 16	Aug. 30	Sept. 14
Carbon dioxide absorbed by unit leaf area during twelve hours <sup>(1)</sup>	"Rikuu No. 132"	35.65	51.78	36.47	35.53	—
	"Husakusirazu"	29.84	46.51	41.30	48.60	34.40

(1) mg. per 50 cm<sup>2</sup>.

Both varieties showed the same tendencies in the change of photosynthetic activity, the maximum of which is in the heading season; the flowering began on August 4th in the early variety and on August 30th in the late variety (Fig. 7).

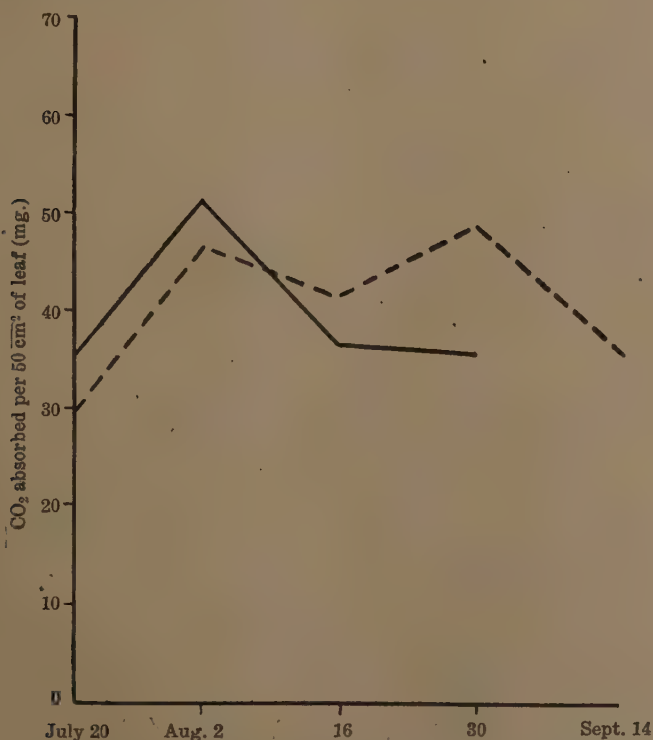


Fig. 7. Seasonal change of photosynthesis under natural conditions. — "Rikuu No. 132", ---- "Husakusirazu".

### 3. Assimilation under different light conditions

The fact was surely proved by the numerous experiments, the results of which have been given previously, that light is a most powerful one among the factors which have influences upon the carbon dioxide assimilation under natural conditions. Then, a few investigations were undertaken to know the effects of insufficient light upon the photosynthesis. On August 4th and 6th, 1937, the amount of carbon dioxide absorbed by a leaf during a unit hour was determined under such a condition as 30 per cent of radiation was reduced by means of a glass, the variety "Rikuu No. 132" being the material. The results are given in Tab. 13

TABLE 13. Assimilation under different light condition (1).

Date	Condition	6 A.M.	9	Noon	3 P.M.	Sum 6-3 A. P. M. M.	Rate of assimilation	Rate of radiation at noon
Aug. 4	Intensity of radiation <sup>(1)</sup>	Natural condition	1.127	1.836	1.674	1.641		100
		Controlled condition	0.870	1.641	1.222	1.417		73
	Carbon dioxide absorbed by unit leaf area per three hours <sup>(2)</sup>	Natural condition	14.22	13.06	6.25	33.53	100	
		Controlled condition	10.45	8.49	4.90	23.84	71	

(1) g. cal. on  $\text{cm}^2$  per minute.

(2) per  $50 \text{ cm}^2$ .

TABLE 14. Assimilation under different light condition (2).

Date	Condition	10 A.M.	Noon	2 P.M.	Sum 10-2 A. P. M. M.	Rate of assimilation	Rate of radiation at noon
Aug. 6	Intensity of radiation <sup>(1)</sup>	Natural condition	1.800	1.289	0.999		100
		Controlled condition	1.322	0.904	0.547		70
	Carbon dioxide absorbed by unit leaf area per two hours <sup>(2)</sup>	Natural condition	7.38	5.91	13.29	100	
		Controlled condition	5.38	3.86	9.24	70	

(1) g. cal. on  $\text{cm}^2$  per minute

(2) per  $50 \text{ cm}^2$ ,

and 14, in which a complete parallelism is found quantitatively between the diminution of light intensity and the deficiency of assimilation; both the rate of light intensity at noon and the photosynthetic activity in day time are 70%.

Similar relation was recognized in the studies of two varieties "Rikuu No. 132" and "Husakusirazu" under the controlled light condition through cotton cloth as indicated in Tab. 15. In this case the actual effect of the radiation upon the assimilation is somewhat different as compared to that through the glass, even if the intensity recorded is the same. It may be caused by the unlike quality of radiation which passed through different media, i.e. glass or cotton cloth.

TABLE 15. Assimilation under different light condition (3).

Date and varieties		Condition	10 A.M.	Noon	2 P.M.	Sum 10-2 P. M.	Rate of assimilation	Rate of radiation at noon
Aug. 14	Intensity of radiation <sup>(1)</sup>	Natural condition	1.350	1.417	1.579			100
		Controlled condition	0.675	0.742	0.932			59
var. "Rikuu No. 132"	Carbon dioxide absorbed by unit leaf area per two hours <sup>(2)</sup>	Natural condition		11.19	7.99	19.18	100	
		Controlled condition		8.02	4.64	12.66	66	
Aug. 26	Intensity of radiation	Natural condition	1.384	1.641	1.350			100
		Controlled condition	1.256	0.804	0.642			49
var. "Husaku-sirazu"	Carbon dioxide absorbed by unit leaf area per two hours	Natural condition		4.99	7.34	12.33	100	
		Controlled condition		2.94	4.25	7.19	58	
Sept. 6	Intensity of radiation	Natural condition	1.512	1.546	0.837			100
		Controlled condition	0.742	0.770	0.257			50
var. "Husaku-sirazu"	Carbon dioxide absorbed by unit leaf area per two hours	Natural condition		11.65	10.49	22.14	100	
		Controlled condition		6.68	6.07	12.75	58	
Sept. 14	Intensity of radiation	Natural condition	1.674	1.741	0.904			100
		Controlled condition	0.837	0.893	0.385			51
var. "Husaku-sirazu"	Carbon dioxide absorbed by unit leaf area per two hours	Natural condition		12.16	11.11	23.27	100	
		Controlled condition		7.15	6.47	13.62	59	

(1) g. cal. on  $\text{cm}^2$  per minute.

(2) per 50  $\text{cm}^2$ .

## Discussion

There are several methods for measuring the apparent rate of photosynthesis, that is, the amount of photosynthetic material produced in excess of the amount of substances used in respiration and transpiration. One of these consists in the quantitative determination of the carbon dioxide absorbed by a definite leaf area. The second general method is based on the determination of organic substances or dry matter accumulated in a unit leaf area during a certain definite period. The third consists in the comparison of the amount of acid hydrolyzable carbohydrates at different periods of the day. The intensity of photosynthesis has been hitherto determined by many investigators with these methods, but no two of them have got similar results even in the study of one and the same kind of plants. It is generally considered that the intake of carbon dioxide is the first step of photosynthesis and the increase in dry matter the last. The above three methods including another simpler one based on the reaction of iodine on the accumulated organic substance in the leaf have been used to study the daily change of photosynthesis under natural conditions in these experiments. Each method has a special characteristics for determining the intensity of photosynthesis, but all the results indicated at least the same tendencies: namely, the activity of photosynthesis in rice-plants under fine weather rises up almost regularly from early morning, reaches its maximum during the first two hours afternoon and then descends rapidly, while the defect of light intensity due to the appearance of clouds in the sky makes it somewhat irregular.

Does a definite mode of change take place during a day in the photosynthetic activities in a definite plant species under normal conditions? THOMAS and HILL (1937) found in the study of wheat and alfalfa grown on field that the assimilation curves are almost symmetrical and they have their peak values at noon. Nearly the same results have been obtained already by KOSTYSCHEW and KARDO-SYSSOIEWA (1930) in wheat and cotton plants, but slight depressions was observed at midday in red clover and alfalfa. MILLER (1924) studied the daily variation of the amount of carbohydrates in corn and sorghum, and found a regular change of that of sugar and insoluble carbohydrates. Such behaviour was also found in coco-nut leaves: the maximum rate came in morning, a depression at midday and a second rise in afternoon, followed by a final decline towards sunset (MCLEAN 1920). On the other hand, irregularities happened very often in the daily change of apparent assimilation even under fine weather (KOSTYSCHEW and KARDO-SYSSOIEWA 1930, KOSTYSCHEW and BERG 1930), which might have been perhaps caused by the variability of external conditions and the incompleteness of measuring methods. In respect to the daily change of carbon dioxide assimilation in rice-plants,



there appeared some difference in different varieties, thus, for instance, the maximum accumulation of organic substances formed by photosynthesis was observed in the morning immediately before the noon, while in the late one it has taken place immediately after the noon, both under fair weather. This difference, however, disappeared when the external conditions became abnormal owing to the cloudiness. From the results of their experiments THOMAS and HILL (1937) concluded that the cloudy weather is reflected by the irregularities in the assimilation curve, which would explain the phenomenon, the disappearance of the varietal characteristic, to some extent.

In the studies of leaves of wheat, linseed and sugar cane SINGH and LAL (1935) found the gradual decrease of photosynthetic efficiency in the progress of development, and BOONSTRA (1936) proved thereafter the same fact experimentally on the basis of starch formation in leaves, which were translocated to the ripening seeds of wheat. A similar result was obtained with rice-plants by the author by comparing the activity of assimilation at the top and the third leaf. The cause of such a decline of photosynthesis with the age of leaves was indicated by the two researchers above mentioned, viz. that the thickness of palisade cell in older leaves reduces the carbon dioxide reaching to the deep-seated chloroplasts which do not, therefore, function as efficiently as in young leaves.

The photosynthetic activity of rice-plants is apt to rise from a certain stage of development up to a definite period of the life-cycle, in which the flowering is just coming, and subsequently shows a tendency of decreasing. In wheat the seasonal variation of assimilation reaches its maximum at the flowering time (THOMAS and HILL 1937) and the amount of sugars including saccharose, glucose and fructose, is maximum after blooming due to the high rate of photosynthesis in the foregoing stage (BARNELL 1936). It is generally considered that at least in the cereals, the maximum assimilation takes place in the heading season. Consequently, a varietal difference in the changing mode of photosynthesis begins to appear with the progress of development, both in early and late ripening varieties of rice-plants.

Among the external factors, which have influences upon the rate of photosynthesis, light is most powerful under natural conditions, as BLACKMAN and MATTHAEI (1905) indicated that the assimilation of carbon dioxide progresses in proportion to the light intensity in the limit of arriving solar radiation on the ground. MUNTZ (1913), PORTER (1937), THOMAS and HILL (1937), BOLAS, MELVILLE and SELMAN (1938), WAUGH (1939), all have confirmed experimentally the above opinion, except LUBIMENKO (1915), who admitted in heliophilous plants the relation to an optimum point and HEINICKE and CHILDERS (1936) and SCHODER (1932), who admitted the fact only in case of low and high

average light intensity. Almost complete parallelism was also found in rice-plants between the light intensity and the intensity of assimilation. Attention must be called, however, to the fact that when the action of radiation is artificially controlled by passing through either a glass or cotton cloth, the photosynthetic activities of plants are different even though their intensities are the same as recorded on the actinograph. It would be probable that the qualities of radiation are altered by passing through different media.

Here, the author likes to add some words about the rate of photosynthesis. Different degrees of photosynthetic activity have been, hitherto, measured per unit area of leaf during a definite period in different kinds of plants. SACHS (1884) found the increase of 1.7–1.9 gr. weight in one square meter per hour in *Helianthus* and of 1.5 gr. in *Cucurbita* by his half-leaf method. BROWN and ESCOMB (1905), on the contrary, found only 0.4–0.5 gr. carbohydrate increase in the same unit leaf area of *Helianthus*, and recently, PICKETT (1935) found in the two varieties of apples only 0.12–0.15 gr. increase of dry weight per hour in average of twelve hours measurement under fine weather. In these experiments some very high values were occasionally found by the dry-weight method, for instance, 2.8 gr. and 1.7 gr. increase of dry weight per hour, but in average not more than 1.2 gr. On the other hand, many investigators have determined the average rate of photosynthesis by the gas-stream method and have got the following values (Tab. 16).

TABLE 16. The amount of photosynthetic activity measured by the gas-stream method.

Light condition	Materials	Carbon dioxide absorbed 50 cm <sup>2</sup> per hour (mg.)	Investigators
Under sun light	<i>Alchemilla</i>	15.0	KOSTYTSCHIEW, BAZYRINA and TSCHESNOKOV (1928)
	<i>Betula</i>	9.8	"
	<i>Plantago</i>	11.0	"
	<i>Alchemilla</i>	3.3	BOYSEN-JENSEN and MÜLLER (1929)
	<i>Betula</i>	2.8	"
	<i>Plantago</i>	4.8	"
	Tomato	4.2	BOLAS, MELVILLE and SELMAN (1938)
	Sugar cane	1.9	MCLEAN (1929)
	Coco-nut	0.14–0.44	"
Under arc light	<i>Geranium</i>	8.3	MITCHELL (1935)
	Tomato	8.5	"
	Primrose	6.6	"
	<i>Cineraria</i>	6.6	"
	Waxbean	6.6	"
	Rice-plant	16.5–15.3	MITUI (1938)

A considerable variation is found in the values in the table, and on the whole, the rate of apparent photosynthesis measured under arc light is higher than the average rate determined under natural conditions. The results obtained in these experiments with rice-plants under natural conditions are also variable and range between 6.7–1.4 mg. carbon dioxide absorbed by  $\text{cm}^2$  per hour. HEINICKE and HOFFMAN (1933 b) gave the following opinions about the comparatively high value in the study of apples, namely, that some very high values are occasionally found during brief periods, but these are offset by lower rate in subsequent determinations. Using four different kinds of plants, *Helianthus*, *Tropaeolum*, *Bomarea* and *Aponogeton*, BLACKMAN and MATTHAEI (1905) investigated the question, whether the different type of leaves had different specific photosynthetic characters, and from the results obtained by them they concluded that the leaves in general had the same "coefficient of economy" in the photosynthetic process. In the latter statement their assumption of "equal coefficients of economy" was still held by pointing that *Helianthus* requires twice as much light to attain the double assimilation at  $29.5^\circ\text{C}$ . The fundamental existing specific differences would seem to lie in their different coefficients of acceleration of activity with increase in temperature. In short, a leaf of a definite kind of plants must have a definite power of photosynthetic activity as a genetical character, but it may be influenced by the outer conditions, so that the real value has not yet been found.

### Summary

(1) The photosynthetic activity of leaves in rice-plants has been studied under natural conditions with four different methods, i.e. the iodine reaction, the weight-area method, the saccharification method and the gas-stream method.

(2) The intensity of carbon dioxide assimilation under fair weather rises up almost regularly from early morning, reaches its maximum at noon and then descends rapidly, though the defect of light intensity due to the cloudiness makes it irregular.

(3) Under fine weather a varietal difference appears in the daily change of photosynthesis: in the early variety, the maximum accumulation of organic substances formed by assimilation occurs in the morning, immediately before the noon and in the late one immediately after it.

(4) The activity of photosynthesis in rice-plants is apt to rise towards the stage, where the flowering is just coming, and subsequently shows a tendency of decreasing.

(5) An almost complete parallelism is found between the intensity of carbon dioxide assimilation and the light intensity.

In conclusion the writer wishes to express his sincere thanks to Mr. Tomota SUGAWARA for his help rendered in this work. A part of the expense of this work was defrayed out by a grant from the Japan Society for the Promotion of Scientific Research.

### Literature cited

- 1) BARNELL, H. R.: Seasonal changes in the carbohydrates of the wheat plant. *New Phytologist* **35**: 229, 1936.
- 2) BLACKMAN, F. F. and MATTHAEI, G. L. C.: Experimental researches in vegetable assimilation and respiration. IV. A quantitative study of carbon-dioxide assimilation and leaf-temperature in natural illumination. *Proc. Roy. Soc., B.* **76**: 402, 1905.
- 3) BLACKMAN, F. F. and SMITH, A. M.: Experimental researches on vegetable assimilation and respiration. IX. On assimilation in submerged water plants and its relation to the concentration of carbon dioxide and other factors. *Proc. Roy. Soc., B.* **83**: 389, 1911.
- 4) BOLAS, B. D.: The influence of light and temperature on the assimilation rate of seedling tomato plants, Variety E. S. I. *Exp. and Res. Sta. Cheshunt Herts. Ann. Rpt.* **79**: 84, 1933.
- 5) BOLAS, B. D., MELVILLE, R. and SELMAN, I. W.: The measurement of assimilation and translocation in tomato seedlings under the condition of glass-house culture. *Ann. Bot. N. S.* **2**: 717, 1938.
- 6) BOONSTRA, A. E. H. R.: Der Einfluss der verschiedenen assimilierenden Teile auf den Samenertrag von Weizen. *Zeitschr. f. Züchtg. Pflanzenzüchtung* **21**: 115, 1936.
- 7) BOYSEN-JENSEN, P.: Über neue Apparate zur Messung der Kohlensäureassimilation, der Respiration, der Öffnungsweite der Spaltöffnungen und der Beleuchtungsstärke. *Planta* **6**: 456, 1928.
- 8) BOYSEN-JENSEN, P. und MÜLLER, D.: Die maximale Ausbeute und der tägliche Verlauf der Kohlensäureassimilation. *Jahrb. wiss. Bot.* **70**: 493, 1929.
- 9) BROWN, H. T. and ESCOMBE, S.: Researches on some of the physiological process of green leaves, with special reference to the interchange of energy between the leaf and its surrounding. *Proc. Roy. Soc., B.* **76**: 29, 1905.
- 10) HEINICKE, A. J. and HOFFMAN, M. B.: An apparatus for determining the absorption of carbon dioxide by leaves under natural conditions. *Science* **77**: 55, 1933 a.
- 11) HEINICKE, A. J. and HOFFMAN, M. B.: The rate of photosynthesis of apple leaves under natural conditions. Part I. *Corn. Univ. Agr. Exp. Sta. Ithaca. Bull.* **577**, 1933 b.
- 12) HEINICKE, A. J. and CHILDERS, N. F.: The daily rate of photosynthesis, during the growing season of 1935, of a young apple tree of bearing age. *Memoir* **201**, *Corn. Univ. Agr. Exp. Sta.* 1936.
- 13) KOSTYSCHEW, S., BAZYRINA, K. und TSCHESNOKOV, W.: Untersuchungen über die Photosynthese der Laubblätter unter natürlichen Verhältnissen. *Planta* **5**: 696, 1928.



- 14) KOSTYSCHEW, S. und KARDOSYSSOIEWA, H.: Untersuchungen über den Tagesverlauf der Photosynthese in Zentralasien. *Planta* **11**: 117, 1930.
- 15) KOSTYSCHEW, S., und BERG, V.: Untersuchungen über den Tagesverlauf der Photosynthese in Transkaukasien. *Planta* **11**: 144, 1930.
- 16) LUBIMENKO, M. W.: Sur la sensibilité de l'appareil chlorophyllien des plantes ombrophiles et ombrophobes. *Rev. Gén. Bot.* **17**: 381, 1915.
- 17) MATTHAEI, G. L. C.: Experimental researches on vegetable assimilation and respiration. III. On the effect of temperature on carbon dioxide assimilation. *Roy. Soc. [London]. Phil. trans. B.* **197**: 47, 1905.
- 18) MCLEAN, F. T.: Field studies of the carbon-dioxide absorption of coco-nut leaves. *Ann. Bot.* **34**: 367, 1920.
- 19) MILLER, E. C.: Daily variations of the carbohydrates in the leaves of corn and the sorghums. *Jour. Agr. Res.* **27**: 785, 1924.
- 20) MITCHELL, J. W.: A method of measuring respiration and carbon fixation of plants under controlled environmental conditions. *Bot. Gaz.* **97**: 376, 1935.
- 21) MITUI, S.: On the methods of measuring the carbon dioxide assimilation (in Japanese). *Jour. Sci. Soil. and Man.* **12**: 62, 1938.
- 22) MUNTZ, M. A.: La luminosité et l'assimilation végétale. *Compt. Rend. Acad. Sci. [Paris]*. **156**: 368, 1913.
- 23) NOGUTI, Y. and SUGAWARA, T.: On a method of measuring the carbon dioxide assimilation in some cereals (in Japanese). *Agr. and Hort.* **12**: 3141, 1937.
- 24) NOGUTI, Y.: Studies on the carbon dioxide assimilation in rice-plants (in Japanese). *Proc. Crop. Sci. Soc. Japan.* **10**: 165, 1938.
- 25) PICKETT, Wm. F.: A comparison of three methods of measuring photosynthetic activity of apple leaves. *Proc. Amer. Soc. Hort. Sci.* **33**: 152, 1935.
- 26) POTER, A. M.: Effect of intensity on the photosynthetic efficiency of tomato plants. *Plant Physiology* **12**: 225, 1937.
- 27) SACHS, J.: Ein Beitrag zur Kenntniss der Ernährungsthätigkeit der Blätter. *Arbeiten bot. Inst. Würzburg.* **3**: 1, 1884.
- 28) SCHODER, A.: Über die Beziehungen des Tagesganges der Kohlensäureassimilation von Freilandpflanzen zu den Aussenfaktoren. *Jahr. wiss. Bot.* **76**: 441, 1932.
- 29) SINGH, B. N. and LAL, K. N.: Investigation of the effect of age on assimilation of leaves. *Ann. Bot.* **49**: 291, 1935.
- 30) STANESCU, P. P.: Daily variations in products of photosynthesis, water content, and acidity of leaves toward end of vegetative period. *Amer. Jour. Bot.* **23**: 374, 1936.
- 31) THOMAS, M. D. and HILL, G. R.: 1937. The continuous measurement of photosynthesis, respiration, and transpiration of alfalfa and wheat growing under field conditions. *Plant Physiology* **12**: 285, 1937.
- 32) WAUGH, J. G.: Some investigation on the assimilation of apple leaves. *Plant Physiology* **14**: 463, 1939.



# On the branching of some araliaceous plants with special references to the behaviour of the ramular trace bundles<sup>(1)</sup>

By Riukiti INOUE

With plate III and 15 text-figures

(Received February 3, 1941)

## Introduction

In the majority of the dicotyledonous plants the mode of the vascular supply to the lateral shoots shows a great uniformity, and it was classified by DE BARY (1) into two main types. In most cases the bundles to a branch are given off either from the median foliar trace, or from the bundles which border the median foliar gap, and they are divided into several strands. In the second case the bundles to a branch pursue an individual course through some internodes in the main shoot before they leave the bundle ring. These two types, are, however, identical in such respects, that the connection of bundle systems of shoots of different orders occurs always relating to the median foliar gap, and that there is a direct continuity of their piths.

In some species of Umbelliferae a characteristic mode of the bundle system at the insertion of branch was found by DE BARY (1), which was described as the third type: the bundles to a branch are given off from various portions of the bundle ring of the axis, pass through the cortex in several groups, in which the foliar trace bundle is also included, and after the latter leaves the groups, they unite with each other into one to form the base of the bundle ring of the branch, which embraces the axis. He found this type also in *Aralia japonica*, whose information is, however, brief and does not refer to the behaviour of individual bundles of the ramular trace.

The mode of the insertion of lateral shoots seems to have failed to attract attentions of investigators, probably, because of its uniformity, and so far as I know, we have no information on this third type of

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DE BARY except his own description, and recently OGURA (2) noticed the wide distribution of this type in various species of Araliaceae. In the present paper some details of the course of ramular trace bundles in some araliaceous plants are dealt with.

In my investigations, serial sections were cut from raw or preserved materials, 50 to 120  $\mu$  in thickness. It was found, that adult plants, which present a considerable secondary wood, were convenient to trace the bundle course, though the secondary growth makes the origin of the ramular trace obscure, and to investigate it, observations of thinner sections of younger plants, which bears dormant buds, were necessary. For this purpose the paraffin method was also adopted, and sections were cut 15  $\mu$  thick, and were stained by safranin and DELAFIELD's haematoxylin.

The materials used in the present work were following 20 species, which were collected in various parts of Japan; in Japan proper, in Korea, in Formosa and also in Palao Islands.

*Acanthopanax spinosum* MIQ.

*A. trichodon* FRANCH. et SAV.

*A. divaricatum* SEEM.

*A. seoulense* NAKAI

*A. sessiliflorum* SEEM.

*Aralia cordata* THUNB.

*Boerlagiodendron pulcherrimum*  
HARMS

*Brassaia actionphylla* F. MUELL.

*Echinopanax japonicum* NAKAI

*Fatsia japonica* DECNE. et PLANCH.

*Gilibertia trifida* MAKINO

*Hedera Tobleri* NAKAI

*Kalopanax innovans* MIQ.

*K. ricinifolium* MIQ.

*Meryta Senftiana* VOLKENS

*Nothopanax scutellarium* MERR.

*Polyscias grandiflora* VOLKENS

*Schefflera arboricola* HAYATA

*S. octophylla* HARMS

*S. odorata* MERR.

## Observations

*Acanthopanax spinosum* shows the third type of DE BARY in the mode of branching, as it is easily confirmable in the decorticated node, at which a lateral shoot is given off (Pl. III, 1 and 2). This species possesses the foliar trace consisting of five bundles, which leave the bundle ring of the axis closely below the node, each causing its own gap (Fig. 1. A), and are arranged in an arc convex to the outside. Then they ascend in the cortex; meanwhile lateral ones approach gradually to the median. After they come out from the bundle ring their size becomes larger, and they split into several strands (Fig. 1. A; B; etc.), so that there appear five arc-shaped groups of bundles of considerable size (Fig. 1. C). A bundle leaves the middle of each group, producing a small gap (Fig. 1. C-E, shown in black), which is clearly marked in the decorticated material, even after a considerable secondary growth takes place (Pl. III,



1, g). These bundles, five in number, are nothing but the vascular supply to the leaf at the node concerned, and those which are left in the cortex are the ramular trace bundles. They are, at first, arranged in an arc in each of the groups, but later at higher levels, in the groups neighbouring the median (1, 1') several bundles, which are situated on both ends of



Fig. 1. *Acanthopanax spinosum*. 5 $\times$ . In following figures serial sections of the base of branch are depicted, unless no special remarks are given, and following notations are used: m, median foliar trace bundle or median group of bundles; 1, 2, ..... (on the left), or 1', 2', ..... (on the right), order of lateral bundles (or groups) counted from the end of the arc; suffix ad, adaxial bundles; vsscular supply to the leaf, in black.

the arc, change their position adaxially, so as to form a concentric circle of bundles (Fig. 1, C-E). Those bundles pursue a course further adaxially and come at last to a certain distance from their original groups (Fig. 1, F, 2<sub>ad</sub>, 2'<sub>ad</sub>); meanwhile, the groups left in the abaxial side approach to each other to form a large arc (Fig. 1, F). As the bundles run acropetally, they come nearer to each other, and the marginal ones turn somewhat inwards, taking a position between the margins of the adaxial and abaxial bundles (Fig. 1, G). As the result a semicircular bundle system with a fissure in the middle of the adaxial side is formed (Fig. 1, G), which becomes gradually narrower acropetally by the approach of bundles bordering it, and at last is closed at a certain higher level (Fig. 1, H), so that a semicircular bundle system, corresponding to the base of the bundle ring of the branch, is made up.

The course of the bundles of the ramular trace at the insertion of the branch of this species can be summarized as follows: 1) All the

bundles of the foliar trace relate to those of the ramular trace. 2) A few bundles, which are situated on both ends of the groups neighbouring the median migrate to the adaxial side of the bundle ring of the branch. 3) The inner end of the outermost group does not change its position in the formation of the bundle system of the branch. 4) No bundle of the median group takes part in the formation of the adaxial bundle system of the branch. This condition is observable also in the decorticated material, in which the stripes on the adaxial surface of the wood of the branch run downwards separately, to be continuous to those on the surface of the shanks neighbouring the median (Pl. III, 2).

In some instances the base of the lateral shoot is divided into seven shanks; in this case the foliar trace consists of seven bundles, and the condition mentioned above under 1) remains unchanged, and we have two groups of bundles, from each of which a few bundles migrate to the adaxial bundle system, between the median and the outermost ones.

The same was observed in all of the investigated species of this genus; i.e. in *Acanthopanax trichodon*, *A. divaricatum*, *A. seoulense* and *A. sessiliflorum*. The number of foliar trace bundles is five, seven, nine and nine respectively, and in every case all the foliar trace bundles are accompanied by the ramular trace bundles.

In the last species there is, however, a slight modification. In Fig. 2, A we can see nine bundles or groups of bundles starting from the bundle

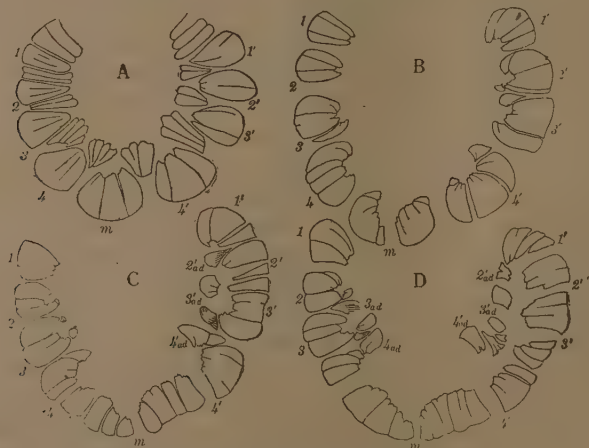


Fig. 2. *Acanthopanax sessiliflorum*. 5x.

ring of the main axis. In the same figure the median and two lateral bundles (m, 3', 4'), and in the next figure, B, all the bundles, are divided into several strands forming an arc-shaped group. In the latter figure

it is also remarked, that only the outer end of the arc neighbouring the median is turning adaxially (4, 4'), and it is accentuated in Fig. 2, C, in which the outer end projects strongly adaxially (4'<sub>ad</sub>), and the inner arm (4, 4') comes in contact with the arms of the median group, indicating that no bundle migrates to the adaxial bundle system of the branch from the inner end of these groups. All the other lateral groups show the same behaviour as in the species above described (Fig. 2, D). It is notable that in all the investigated species of this genus the bundle course at the insertion of the branch is all the same, regardless to the number of the foliar trace bundles, though a slight modification is found in a species.

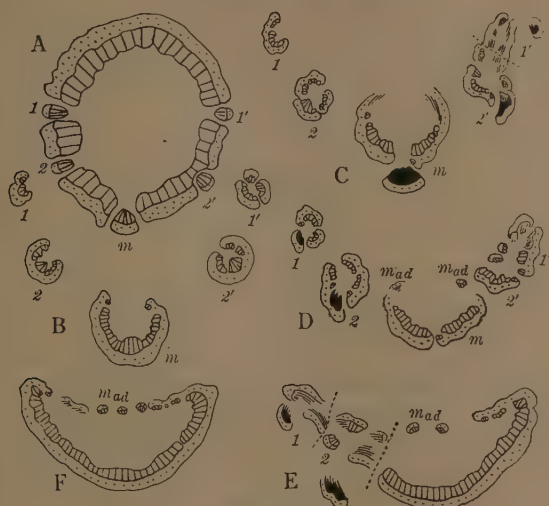


Fig. 3. *Hedera Tobleri*. 12x.

*Hedera Tobleri* shows different conditions. It has also foliar traces consisting of five bundles as *Acanthopanax spinosum*. They leave the bundle ring of the axis causing as many foliar gaps in it (Fig. 3, A). On both sides of the foliar trace bundles, there develop some bundles of the ramular trace, and they form together an arc, which assumes the shape of a circle later at higher levels (Fig. 3, B-D). From both ends of the arms of the median group a small portion is cut off and runs adaxially (Fig. 3, C and D, *m<sub>ad</sub>*), which is seen in the base of the branch on the adaxial side (Fig. 3, E, *m<sub>ad</sub>*). In this manner a few bundles migrate adaxially from the median group, so as to form a part of adaxial bundle system in the lateral shoot. As to the behaviour of this group, it is to be noted, that very often the adaxial bundle system of the branch receives bundles merely from one end of the arc of this group, and I

could find no instances, in which the median group did not take part in the formation of the adaxial bundle system of the lateral shoot.

There is another difference in the course of the bundles of the outermost group. In Fig. 3, B and D the bundles are arranged in a circle in these groups (1, 1'), which are then divided into two parts—an adaxial and an abaxial, and then these groups run transversely in pair to come in contact with the neighbouring group (Fig. 3, C and E). Comparing the size and form of those two parts with those of the original group, it is evident that a portion of the inner end changes its position to affix itself on the other end of the same group, and it forms a part of the adaxial bundle system of the lateral shoot. The same was observed not only in this species, but also in all the investigated plants except those of *Acanthopanax*, though it was not always clearly ascertainable.

The groups neighbouring the median take part in the formation of the adaxial bundle system, as in species of *Acanthopanax*, giving off a few bundles situated on both ends to the adaxial side.

In young plants of *Fatsia japonica*, which bear simple, unlobed leaves, there are five foliar trace bundles at a node, all of which relate to the ramular trace bundles; the course of the latter is just the same as that of *Hedera Tobleri*. In adult plants we find fifteen to nineteen foliar trace bundles at a node, but the condition of the bundle system remains unchanged at all. An example, in which the foliar trace consists of eighteen bundles, will be illustrated. A cross section closely below a node, which bears a well developed branch, shows a bundle ring with a wavy outline (Fig. 4, A), its projections being composed of bundles of foliar and ramular traces. At a higher level these projections are more conspicuous; at first two outer ones on the left separate from the bundle ring of the axis and fuse with each other into a closed ring (Fig. 4, B, 1-2). Next figures, C and D, show two cross sections through higher levels; in C three of the outer groups are free from the bundle system of the axis on both sides and connect themselves with each other to form a ring (1-3, 1'-3'), and some of other groups form an arc or a ring by themselves; in D five outer groups come in contact, forming together a bundle ring on both sides (1-5, 1'-5'), and between them there are eight rings separated from each other. It can be easily comprehended, that each of the groups of ramular trace bundle, which is at first arc-shaped, assumes a form of a closed ring by the gradual increase of the curvature of the arc, so that the bundles on its adaxial side is derived from those located on the end of the arc. In fusing the groups are divided tangentially into two parts, and the bundles on the adaxial side, as well as on the abaxial, come in contact with each other, so as to make a crescent-shaped bundle system, in which a wide fissure is present in the middle of the adaxial side (Fig. 4, E).



As the behaviour of the outermost group is not shown clearly in those figures, it is illustrated in Fig. 4, F, G and H, in which a lump of bundles is seen. A careful study proves that it is composed of three groups of bundles, and the demarcations between them are indicated by

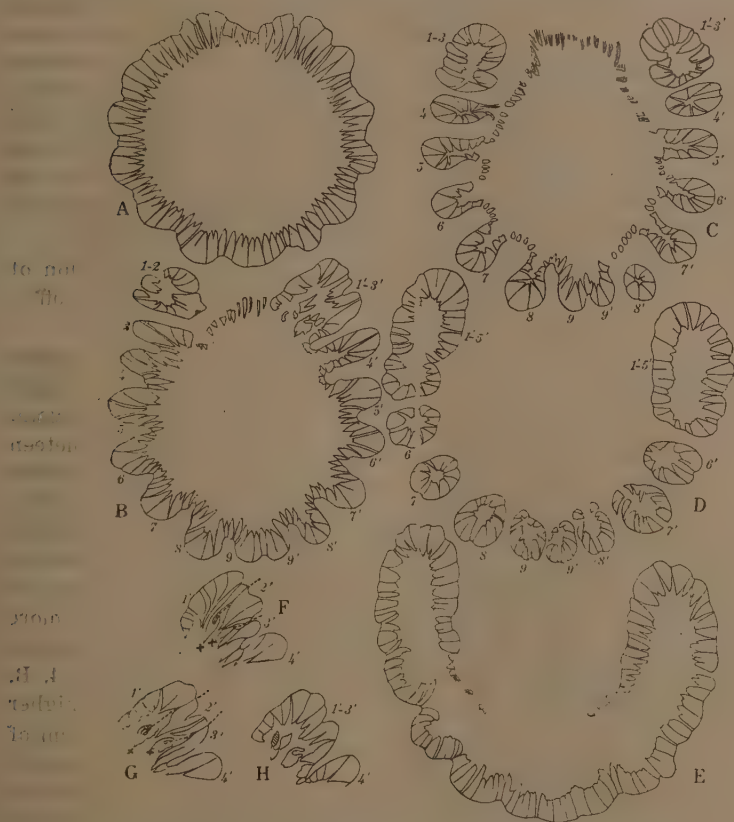


Fig. 4. *Fatsia japonica*. F—H; outer portion of the ring; broken line, demarcations of groups; X, bundle of axis. 3x.

two broken lines, and also by two bundles of the axis marked with a cross. This condition is more conspicuous in G, in which numbers of bundles are arranged in a shape of 3, and opposite to it there are two small groups provided with two arms stretched outwards. Then these arms separate from the bundle of the axis, so as to form the adaxial side of the ring composed of those three groups (Fig. 5, G and B), so it is evident that these arms represent the bundles on the end of each of the

groups, and that the portion shaded in those figures corresponds to the inner end of the outermost group. Therefore, the behaviour of this group is evidently the same as that in *Hedera Tobleri*.

In three other species, namely in *Shefflera arboricola*, *S. octophylla* and *S. odorata*, the same condition is found. The number of foliar trace bundles, as well as that of the shanks, is nine to fourteen, thirteen or fourteen and thirteen respectively.

The mode of the bundle course at the insertion of branch in *Kalopanax ricinifolium* differs slightly from that mentioned in foregoing pages, though the course of the bundles is, so far as it concerns those of the ramular trace, entirely the same as in *Hedera Tobleri*, as illustrated in Fig. 5. In this figure we have seven groups of bundle, among which two outer ones on both sides lie apart from the wood of the axis (A); in the next figure another group on the left becomes free (3). All the

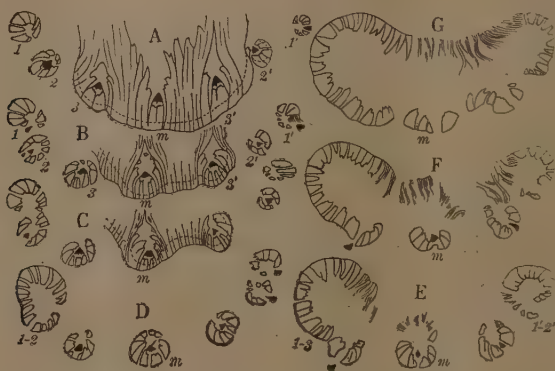


Fig. 5. *Kalopanax ricinifolium*. Broken line, boundary of annular rings. 3 $\times$ .

groups, which separate from the wood of the axis are circular, and fuse one by one at successive higher levels in the manner already described in the foregoing species (Fig. 5, C-G). It is characteristic, that the adaxial bundle system of the lateral shoot receives a considerable amount of vascular elements, so that there is no fissure in the adaxial side, when the crescent-shaped base of the branch is formed (Fig. 5, G).

The difference lies in that not all the leaf trace bundles are connected with the ramular trace, that is, the number of groups of the ramular trace bundles is less than that of the foliar trace bundles; the foliar

trace consists of thirteen bundles, and there are only seven groups of ramular trace bundles, so that six of the former, three on both sides, stand in no relation with the latter, and such bundles are always situated out of the arc, in which the groups of the ramular trace bundles are arranged.

*Nothopanax scutellarium* shows a similar mode to that of *Kalopanax ricinifolium*, but the bundles of foliar trace, as well as the groups of ramular trace bundles, are not always arranged in symmetry. In an investigated material six bundles are on the right to the median one, and seven on the left, and ramular trace bundles are in eleven groups, four on the right and six on the left, so that two outermost foliar trace bundles on the right and one on the left remain without any relation with the ramular trace. The number of the foliar trace bundles, as well as that of groups of ramular trace bundles, is in this species variable, but the condition of bundle system is always the same.

The same is ascertained also in *Meryta Senffiana*. There are more than fifteen bundles of the foliar trace, and less groups of ramular trace bundles. In two investigated materials thirteen groups are found (Fig. 6), and two outermost bundles of foliar trace on both sides are unrelated with the ramular trace. As for the ramular trace bundles of the median group, it must be remarked, that in one of the investigated materials their behaviour is the same as that in *Hedera Tobleri*, that is, some of them migrate to the adaxial side of the branch, while in the other it does not occur, all of them remaining on the abaxial side as in species of *Acanthopanax*. In short, two different sorts of the behaviour of the median group are present in one and the same species.

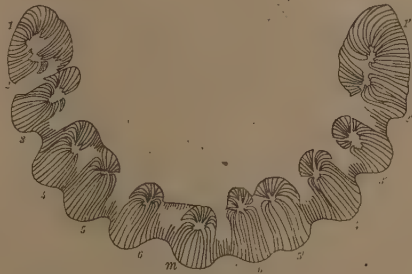


Fig. 6. *Meryta Senffiana*. Cross section of shanks, near the base of the bundle ring of branch, showing their secondary connection. 3x.

Also in *Boerlagi dendron pulcherrimum* and *Brassaia actinophylla* there are the foliar trace bundles which are not in any relation with the ramular trace, as in *Kalopanax ricinifolium* etc. But such bundles are in these two species scattered over all the parts in the arc of the foliar trace; namely, several of such bundles lie nearer to the median bundle than some groups of ramular trace bundles. In this respect these two

species are different from those above mentioned. At a node of *Boerlagiodendron pulcherrimum*, for instance, there are thirty foliar trace bundles and fifteen groups of ramular trace bundles; in another among thirty-five foliar trace bundles only ten stand in relation with the ramular trace. The arrangement of the foliar trace bundles is shown in the following table:

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, *m*, 16', 15', 14', 13,  
12', 11', 10', 9', 8', 7', 6', 5', 4', 3', 2', 1'

OR

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, *m*, 18', 17',  
16', 15', 14', 13', 12', 11', 10', 9', 8', 7', 6', 5', 4', 3', 2', 1'

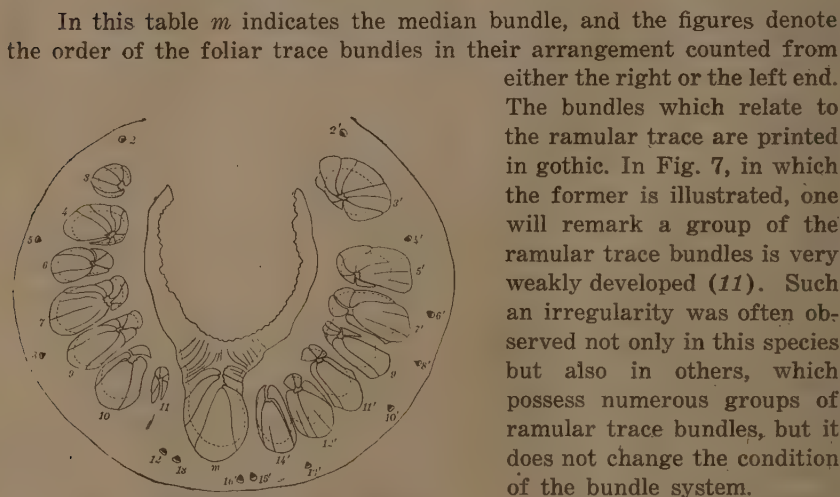


Fig. 7. *Boerlagiodendron pulcherrimum*.  
Base of shanks; broken line, boundary of  
annular rings. 3×.

*Brassaia actinophylla*, and in one of the investigated cases there are nineteen foliar trace bundles, among which twelve relate to the ramular trace, which are arranged as follows:

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, *m*, 8', 7', 6', 5', 4', 3', 2', 1'

It is known that in some species of this family the medullary bundles are present. According to SANIO (3) they are cauline bundles in *Aralia racemosa*. On the contrary WEISS (5) said, that they were common to



leaf and stem, and he observed in *Aralia edulis* that, they entered into the pith from the normal ring with a rotation of  $180^\circ$  at a certain node, and the foliar trace bundles diverged from the normal ring. As for the relation between the medullary and ramular trace bundles, DE BARY (1) cited REICHARDT's work on Umbelliferae, that no direct continuity was found between the medullary bundles of the branch and those of the axis. Among the investigated species *Polyscias grandiflora* and *Aralia cordata* possess medullary bundles. In the former, though it was not available to trace the course of the ramular trace, it was confirmed, that the medullary bundles had no relation with the bundle system of the branch. In the latter, contrary to REICHARDT's statement, the continuity of medullary bundles of axis and bundles of branch, including medullary ones, was evidently observed.

*Aralia cordata* has the foliar trace consisting of innumerable bundles, its width being equal to the whole circumference of the axis, and medullary bundles, most of which are oriented inversely and arranged in an irregular circle opposite to the normal ring in the axis (Fig. 8, A). In accordance with WEISS's observations, two small medullary bundles (*w*) enter into the foliar gap caused by a foliar trace bundle (*b*), fusing with one another into a single bundle, and occupy the space to close the gap (Fig. 8, B-D). The fact, that the bundle *b* is not accompanied by any other vascular bundles, indicates that this bundle stands in no relation with the ramular trace. On the contrary another foliar trace bundle (*a*) is accompanied by several bundles, which are the ramular trace bundles. As the former leaves the bundle ring, a small group of vascular elements is detached from its neighbouring bundles (Fig. 8, E, dotted). Meanwhile two medullary bundles situated near the bundle *a* (Fig. 8, A, *x*, *y*) approach to the latter, dividing into several smaller strands (Fig. 8, D and E), some of them are left in the pith, and others come out through the foliar gap made by the latter (Fig. 8, F and G). At this time another bundle ramifies from a medullary bundle, which lies somewhat deeply in the pith, passes outwards through the gap (Fig. 8, G, *z*). All the bundles, which ramify from the medullary bundles, are arranged in a circle opposite to the foliar trace bundle (Fig. 8, H, in black), and they are rearranged in the following way. The bundles which are derived from the border of the foliar gap, and which have hitherto been situated near the foliar trace bundle, join in the group of those from the pith, forming together an arc opposite to the foliar trace bundle (Fig. 8, I), and then they are rearranged again in a crescent (Fig. 8, J). This group then splits into two circular groups (Fig. 8, K and L), which unite again into a single bundle ring, when the foliar trace bundle comes to a certain distance from the group (Fig. 8, M). As the rearrangement proceeds, the bundles increase in number, giving off several strands, which

are to be medullary bundles in the branch, into the interior of the bundle ring (Fig. 8, L and M). This bundle ring corresponds to one of the

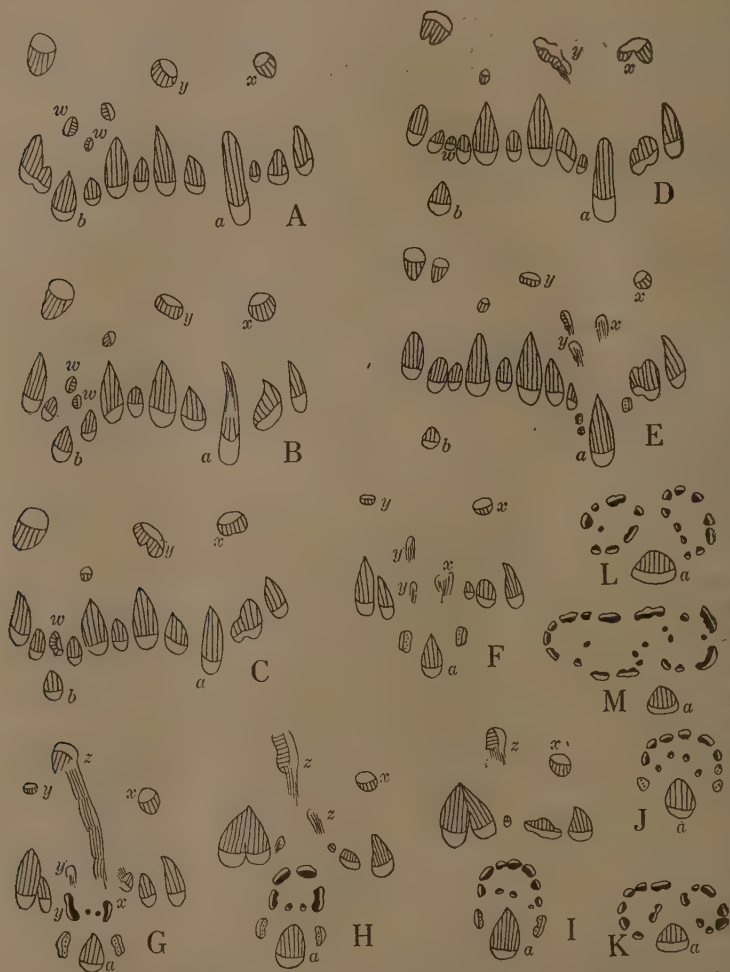


Fig. 8. *Aralia cordata*. *a*, *b*, foliar trace bundle; *w*, medullary bundle entering to normal ring, *x*, *y*, *z*, medullary bundle to branch. (shown in black in G—J); ramular trace bundle from normal ring, dotted (E—J); bundles of shank, in black (K—M). 20×.

shanks of the base of the branch, so that it can be said, that the medullary bundles of the branch appear early even in the shanks, before they form together the bundle ring of the branch. As for the origin of



Fig. 9.

*Aralia cordata*. Radial section through node: *b*, base of bud; *l*, base of leaf; *m*, *m'*, medullary bundles; *n*, bundles of normal ring. 3×.

the medullary bundles in the branch, it is evident that some of them are derived from the medullary bundles of the axis, while others are continuous to the bundles given off from the border of the foliar gap. The continuity between the bundle of the branch and the medullary bundle of the axis is confirmed also in tangential sections of the node, in which we can clearly observe the latter extending to the base of the axillary bud across the normal ring of the axis (Fig. 9, *m*).

This species is similar to *Boerlagiodendron pulcherrimum* or *Brassaia actinophylla* in the arrangement of the foliar trace bundles which do not relate to the ramular trace; some foliar trace bundles like as *b* stand in no relation with the ramular one, and such bundles can lie between any two groups of the ramular trace bundles.

### Origin and secondary development of ramular trace

In foregoing pages the origin of the ramular trace bundles was not referred to, and they are expressed, only for convenience' sake, as branches of the foliar trace bundles, or as those of the bundles bordering the foliar gap. In following lines the origin of ramular trace will be dealt with.

It is depicted in Fig. 10 serial sections of a group of bundles of *Hedera Tobleri*, in which a considerable development of the secondary wood has taken place. The foliar trace bundle (Fig. 10, A, *ft*) bends outwards from the bundle ring of the axis, accompanied by a portion of both neighbouring bundles bordering the foliar gap (Fig. 10, *rt*). While the former ascends, the

latter is divided into several strands, so that the group assumes a shape of an arc (Fig. 10, B), which becomes larger more and more acropetally (Fig. 10, C and D). Those laterally situated bundles enter into the branch, suggesting that the ramular trace bundles are branches of bundles bordering the foliar gap. The similar conditions is observed also in other

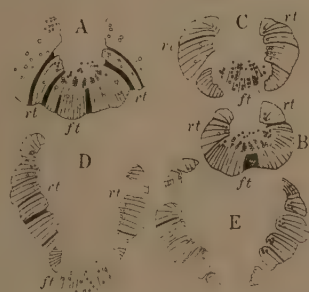


Fig. 10. *Hedera Tobleri*. Serial sections of median group; *ft*, foliar trace bundle (closely striped); *rt*, ramular trace bundle; ray tissue, in black or in thick line. 30×.

species, as described in *Aralia cordata* (Fig. 8), but in strict sense, it is not correct, as will be referred to later.

At a higher level it is observed that the secondary development is much weakened in the middle of the foliar trace bundle, which causes a depression in its outline, and there appears a wide ray tissue in the secondary wood (Fig. 9, B), which is to be replaced by a thin-walled tissue in higher region, so as to cause a gap (Fig. 10, C). The latter becomes wider by the disappearance of the secondary wood, and through which the foliar trace bundle, consisting only of primary elements, passes outwards (Fig. 10, C and D). However, the secondary wood of the foliar trace bundle does not disappear entirely; a small portion on both sides remains intact and is left in the arc, to form a part of the ramular trace (Fig. 10, D and E, closely striped). This suggests that the margin of the foliar trace bundle ramifies as the vascular supply to the branch. It is more clearly illustrated in the inflorescence axis of *Fatsia japonica*, in which the bundle course at the branching of lateral axes is identical to that in the vegetative shoot. A foliar trace bundle (Fig. 11) becomes

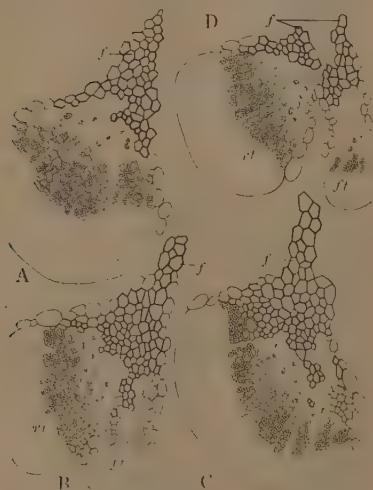


Fig. 11. *Fatsia japonica*. Separation of foliar (*ft*) and ramular (*rt*) trace bundle in inflorescence axis; *f*, fibrous tissue. 80 $\times$ .

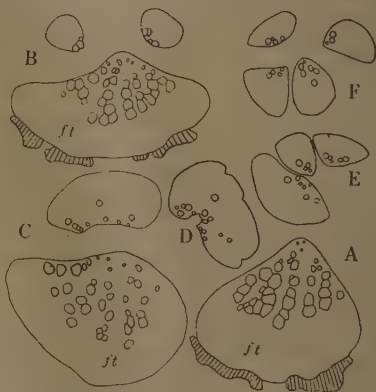


Fig. 12. *Schefflera octophylla*. Serial sections of lateral group; foliar trace bundle is denoted by *ft*, otherwise ramular trace bundles. 90 $\times$ .

broader after it leaves the bundle ring of the main axis (Fig. 11, A), and then a fibrous tissue, which borders the inner margin of the bundle, protrudes into its primary region, as to divide it into two (Fig. 11, B). This process advances (Fig. 11, C), and the foliar and ramular trace bundles separate completely from each other (Fig. 11, D).



This is, however, not always the case, and in some instances no evidence of the ramification of the foliar trace bundle is observable. For example, in the lateral group of bundles in *Schefflera octophylla* there are two ramular trace bundles, one on each side of the foliar trace bundle (Fig. 12, B), which unite with one another into a single bundle situated opposite to the latter (Fig. 12, C). After the foliar trace bends outwards, the ramular trace bundle is divided again into several bundles, so as to make a circular group of a shank (Fig. 12, D-F), in which no elements derived from the foliar trace bundle are present.

Therefore, we have two different relations between the foliar and the lamular trace bundles; namely the former either gives off its portion as a part of the vascular supply to the branch, or has no direct continuity with the latter.

It is noted above, that the ramular trace bundles are not branches of the bundle which borders the foliar gap. It is evident in the node of younger plants, bearing a dormant bud, that no vascular elements ramifies from the border of the foliar gap, when the foliar trace leaves the bundle ring of the axis (Fig. 13, A, 1, 1'). A small procambial strand appears on both sides of the foliar trace bundle later at higher levels, when the latter reaches certain distance from the bundle ring (Fig. 13, A, 2, 2'; and B). These strands then more strongly develop, so that they assume a form of arms of the foliar trace bundle (Fig. 13, A, m; and C), and then they are divided into several smaller strands (Fig. 13, D). The same is ascertained not only in *Acanthopanax spinosum*, which is depicted in these figures, but also in all the investigated materials, which bear dormant buds. This fact suggests, that the ramular trace bundles differentiate newly in the cortex, and that there is no continuity of the primary tissue between the bundle systems

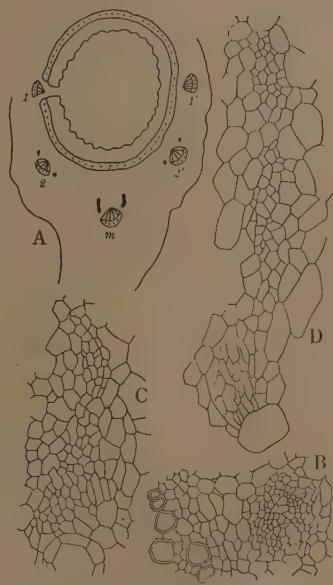


Fig. 13. *Acanthopanax spinosum*. A: cross section of a node, showing position and form of procambial strands (in black), 12x; B-D: procambial strand at successive higher levels; B, 120x, C and D, 170x.

of the axis and the branch, because those procambial strands are undoubtedly the origin of the ramular trace bundles.

The communication of the bundle system between the axis and the

branch is established in later stages of development by the interfascicular cambium. In fact, no primary elements are included in the bundle which is detached from the border of the foliar gap. In Fig. 14 a larger (to the right) and a smaller (to the left) portion is separated from the bundle bordering the foliar gap by a row of ray tissue (*mr*). As the space between the foliar trace bundle and the bundle ring of the axis grows



Fig. 14. *Hedera Tobleri*. Intermediate bundle on the border of foliar gap; *ft*, foliar trace bundle; *mr*, ray tissue. 120 $\times$ .

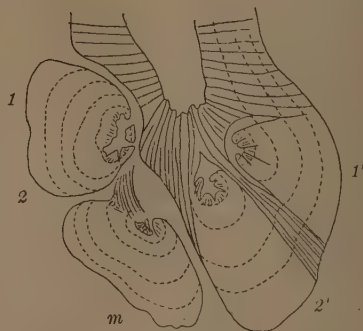


Fig. 15. *Hedera Tobleri*. Cross section of base of a branch, showing the secondary development of wood; broken lines, boundaries of annular rings. 15 $\times$ .

wider, the ray tissue becomes broader and pushes the separated portion outwards, so that the latter accompanies the foliar trace bundle, and acropetally it accomplishes the continuity to the ramular trace bundle. It gives an appearance, as if the bundle bordering the foliar gap gives off its portion as the ramular trace bundle, but this portion is, as remarked above, merely the intermediate bundle, which develops in advanced stages.

The origin of the ramular trace bundles is, in short, to be considered as they newly differentiate in the cortex, and in some cases, some of them are the branches of the foliar trace bundle.

The connection of the bundle systems of branch and axis is strengthened as the secondary wood develops. The cambium appears at first separately in each shank of the branch and forms a concentric woody mass, the development of which is weak on the adaxial side, and is directed outwards on the lateral side (Figs. 2, 4, 5, etc. and 15, *m*). As the secondary thickening of the shanks advances, the spaces between them grow narrower, and at last they come in contact with each other, so that the cambium becomes continuous through the neighbouring shanks (Figs. 7, and 15, 1, 2). In fact this mode of the connection of the shanks takes place at first below the bundle ring of the branch, where the shanks

lie near to each other. It is also the case, that closely below the ring of the branch the cambium of the branch extends downwards, producing the secondary wood, and connects the shanks with each other before their bundles form together the ring of the branch, or they come in contact by their own secondary thickening (Fig. 6). While the secondary growth takes place in the shanks, it occurs of course also in the bundle ring of the axis, though it is much restricted by the presence of the base of the branch (Fig. 7), but when the connection of the wood between the shanks and the axis begins, the wood of the latter protrudes rapidly into the space between the shanks, to make the cambium continuous through the axis and the outer surface of the shanks (Fig. 5; 7; 15, 1, 2'). Naturally, the connection occurs at first closely to the base of the shanks, and as the stage advances, it extends upwards. In this way the secondary connection between the shanks or between the axis and the shank is established from above downwards or from below upwards respectively, so that the characteristic appearance is retained only in the middle of its course (Pl. III, 3 and 4), and at last it becomes invisible externally in the decorticated materials; it is to be noted only in cross sections.

It has been remarked that at the base of the branch there is often a wide fissure on its adaxial side, through which the pith of the branch communicates with the cortex of the axis. When the secondary growth commences, a cambium appears also in this fissure, and produces a secondary tissue, which develops in all directions showing an irregular appearance, and the communication between the pith of the branch and the cortex of the axis is thus disturbed in the well developed branch.

## Conclusions

The mode of the bundle system at the insertion of lateral shoots is greatly uniform in the investigated species of Araliaceae, yet some slight modifications are found. Besides those investigated species *Gilibertia trifida*, *Echinopanax japonicum* and *Kalopanax innovans* were also examined, decorticating the base of branches, and it was ascertained, that they also showed the same.

Among the modifications the presence of the foliar trace bundles which does not relate to the ramular trace bundles, is found in those species, in which the foliar trace consists of numerous bundles, as *Kalopanax ricinifolium*, *Boerlagiodendron pulcherrimum*, *Brassaia actinophylla* and *Aralia cordata*, and never in those which has the foliar trace consisting of less bundles. This fact suggests that this modification may be a natural consequence of the increasing number of the foliar trace bundles. For, if all of them are accompanied by ramular trace bundles, there may be no sufficient space for them in the branch. But it must be

remembered, that in *Fatsia japonica*, in which there are more than fifteen foliar trace bundles at a node, all of them relate to the ramular trace, while *Kalopanax ricinifolium* has only thirteen foliar trace bundles, and yet some of them stand in no relation with the ramular trace. Whereas, this modification can not always be regarded as to relate to the number of the foliar trace bundles, but it may be of some special meaning. The distribution of the foliar trace bundles, which are not in any relation with the ramular trace, can be a characteristic of different species; they are restricted to the outside of the arc of the ramular trace in some species, and in others some of them appear between any two of the groups of the ramular trace bundles.

In species of *Acanthopanax* it is observed, without exception, that the inner end of the outermost group is connected with the neighbouring group in its original position, and is not rearranged to form a part of the adaxial bundle system, while in all other investigated species such a case is not found. *Acanthopanax* is characterized also by another modification, in which the ramular trace bundles of the median group do not take part in the formation of the adaxial bundle system of the branch. It was confirmed also in the decorticated material of *Kalopanax innovans*, while in *Kalopanax ricinifolium* it is not the case. However, this modification may be of less meaning, for in one and the same species, as in *Meryta Senftiana*, the bundles of the median group can either migrate to the adaxial side, or remain abaxially.

As for the medullary bundles two different conditions are found. In *Polyscias grandiflora* they are never in continuity with the bundle system of branches, while in *Aralia cordata* some of them are continuous to the bundles, even to the medullary, of branches. The medullary bundles in the periphery of the pith of the latter species may be, therefore, not always common to leaf and stem, contrary to WEISS's (5) view. More exact study on the nature of the medullary bundle seems to be necessary.

It is generally accepted, that the node is one of the conservative region of the anatomical features of the bundle system. The great uniformity of the mode of the branching in the investigated materials supports well this view. Moreover, it is able to suppose, that in most members, if not in all, of this family the same might be shown, for the species investigated here are distributed widely among the different tribes of this well-defined family, though they include merely a few species and genera.

This type of the branching is found, as remarked above, in some umbelliferous plants, but it has never been observed in Cornaceae. I examined also several species of this family, and found that the ramular trace related invariably only to the median foliar gap. This fact well coincides with SINNOTT's (4) work, that among Umbelliflorae, Cornaceae



possesses the node of the trilacunar type, while Umbelliferae and Araliaceae show the multilacunar type. It suggests that in this order the former family should be situated somewhat remote from two others.

### Summary

1) The mode of the bundle system at the insertion of the lateral shoot, which was described by DE BARY as the third type, is observed in all the investigated species of Araliaceae, and it is supposed that most members of this family might show the same. This type differs from those which are found in most dicotyledonous plants, in that more than two foliar gaps relate to the ramular trace. In the present paper some details of the course of individual bundles of the ramular trace are treated.

2) The ramular trace bundles differentiate newly in the cortex and originally they are in no direct continuity with the bundle system of the axis. In some cases a small portion of the vascular supply to the branch is derived from the foliar trace bundle.

3) The medullary bundles of *Aralia cordata* partly show the direct continuity with the bundles of the branch, but in *Polyscias grandiflora* it is not the case.

4) In some species all the foliar trace bundles stand in connection with the ramular trace, but in those, which possess the foliar trace consisting of numerous bundles, there are several foliar trace bundles, which relate to no bundles of the ramular trace. There are some other modifications, which are also described.

I wish to express my thanks to Dr. YUDZURU OGURA, under whose leading this work was carried on, for his kind suggestions and criticisms, and for the use of materials of his collections.

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### Literature

1. BARY, A. DE, (1877): Vergleichende Anatomie der Vegetationsorgane der Phanerogamen und Farne. Leipzig, 1877.
2. OGURA, Y., (1937): Problems in plant morphology. XII. (In Japanese). Bot. and Zool. **5**, 1937.
3. SANIO, K., (1864): Über endogene Gefäßbildung. Bot. Zeitng. **22**, 1864.
4. SINNOTT, E. W., (1914): Investigations of the Phylogeny of the Angiosperms. I. The Anatomy of the Node as an Aid in the Classification of Angiosperms. Amer. Journ. of Bot. **1**, 1914.
5. WEISS, J. E., (1883): Das markständige Gefäßbündelsystem einiger Dikotyledonen in seiner Beziehung zu dem Blattspuren. Bot. Centralbl. **15**, 1883.

### Explanation of plate III

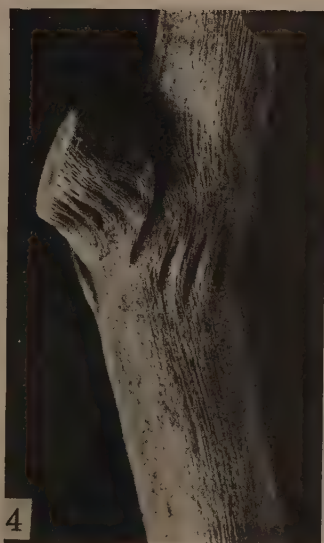
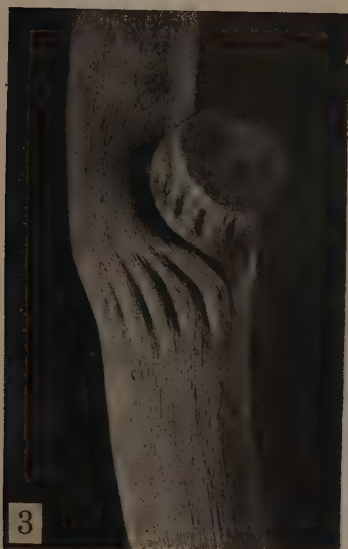
Decorticated base of the branch of:

1. *Acanthopanax spinosum*, lateral view; g, gap on the shank caused by the vascular supply to the leaf. ca. 4,5×.
2. The same, adaxial view; ca. 4×.
3. *Fatsia japonica*, successive two branches are visible; ca. 2×.
4. The same, seen from the other side; the scar of main (inflorescence) axis can be seen on the upper branch; ca. 2×.

### Appendix

While this paper was under press, I was able to observe two other species, namely *Boerlagiodendron marianense* KANEHIRA and *Polyscias subcapitata* KANEHIRA, by the kindness of Mr. T. TUYAMA, who collected them in Rota, Mariana Islands and in Kusaie, East Caroline Islands respectively. The material used of the former species bears only one branch of considerable thickness, which, however, possesses a base embracing the main axis, apparently showing that this species belongs to the third type in the mode of the branching. Decortivating the node, we count about thirty shanks at the base of the branch, whose width reaches more than  $\frac{5}{6}$  of the whole circumference of the axis. It is also observed that there are several scars of the foliar trace bundles on the surface of the wood cylinder of the axis between these shanks, indicating that this species has just the same mode of the branching as *Boerlagiodendron pulcherrimum*. In *Polyscias subcapitata*, we can not find any medullary bundle, though it is the case in *P. grandiflora*. There are about thirty foliar trace bundles, among which seventy or so relate to the ramular trace bundles; their arrangement and the course do not differ in any point from those in the species of *Boerlagiodendron* or *Brassia*.

PLATE III







# Chromosome studies in Cyperaceae, XI. Meiosis in *Carex duvaliana*<sup>(1)</sup>

By Nobunori TANAKA

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With 1 photo. and 13 text-figures

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(Received February 6, 1941)

In *Carex*, the behavior of either extra or multivalent chromosomes in meiosis has been studied in connection with the aneuploidy which is prevailing in this genus. Up to date, many examples which show structural hybridities in their meiosis have been found, while exact researches on the irregular behavior of the multivalents or the extra chromosomes could hardly been carried out, chiefly because of their minuteness and also of rather complicated configurations in their associations at metaphase I. So the species or individuals which always show constant chromosome configurations in meiosis, might throw light on the origin or fate of these extra or multivalent chromosomes. Since the HEILBORN's studies (1924 and sq.) on the chromosomes in the genus *Carex*, a number of species, in which the so-called structural hybridities are present, have been found by several authors (HEILBORN, 1928, 1939, etc.; OKUNO, 1940; TANAKA, 1940 a, b, c; WAHL, 1940). Generally in the first meiotic metaphase of such materials, various transitional modes of chromosome pairing from those having maximum number of multivalents to those having no multivalent chromosomes are present, so it is fairly difficult to search the behavior of either extra or multivalent chromosomes (cf. TANAKA, 1940 a, b, c; WAHL, 1940). The writer has also observed such structural hybridities in several *Carex* species grown in Japan. In most cases, the mode of chromosome pairing at metaphase I varies in a different range according to the different degrees of structural changes or aberrations in the chromosome set or sets.

Fortunately, however, in one plant of *Carex duvaliana* the writer has met with a simple case where the mode of chromosome pairing is practically constant. The plant in question has 76 chromosomes in somatic cells (TANAKA, 1939b), and in the metaphase I a chromosome

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(1) Contributions from the Divisions of Plant-Morphology and of Genetics, Botanical Institute, Faculty of Science, Tokyo Imperial University, No. 269.

configuration of  $36_{II}+1_{III}+1_I$  has been observed in 98.3% of PMCs. The behavior of univalents in meiosis of *Carex* has been a subject of interest in regard to the problem of polysomy. HEILBORN (1928) and WAHL (1940) have suggested the possibility that the polysomatic change in chromosome numbers would be caused by the successive divisions of univalents at both metaphases I and II. The present investigation may also contribute to this problem.

### Material and method

In the present investigation, one plant of *Carex duvaliana* FRANCH. et SAV. collected at Mt. Kiyosumiyama in Tiba Prefecture, labelled Kiyosumi No. 1, was used. The number of somatic chromosomes of this plant is  $2n=76$  (TANAKA, 1939b).

Male spikes were fixed with CARNOY's solution with 3 parts of absolute alcohol and 1 part of glacial acetic acid, and preserved in 75% alcohol after being washed with 95% alcohol as far as it was necessary. Observations were made in the acetocarmine preparations of these materials which were sealed with "valap".

### Observations

IM 174 PMCs at this stage were observed and three types of chromosomes associations, i.e.  $35_{II}+1_{IV}+2_I$ ,  $37_{II}+2_I$ , and  $36_{II}+1_{III}+1_I$  were found. The last configuration (photo. 1; fig. 1) was most prevalent and was seen in 171 PMCs. Fig. 2 shows a plate with 37 bivalents and 2 univalents; fig. 3 a plate with 35 bivalents, 2 univalents and one quadrivalent. From the observed frequency (table 1) it will be seen that the chromosome configuration with  $36_{II}+1_{III}+1_I$  is most prevalent and it may also be accepted that this configuration is practically constant.

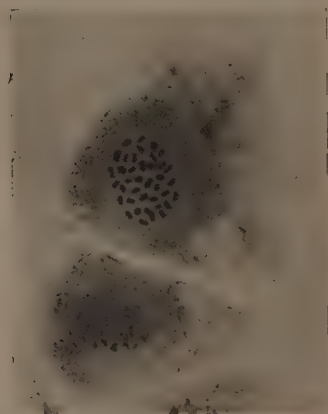


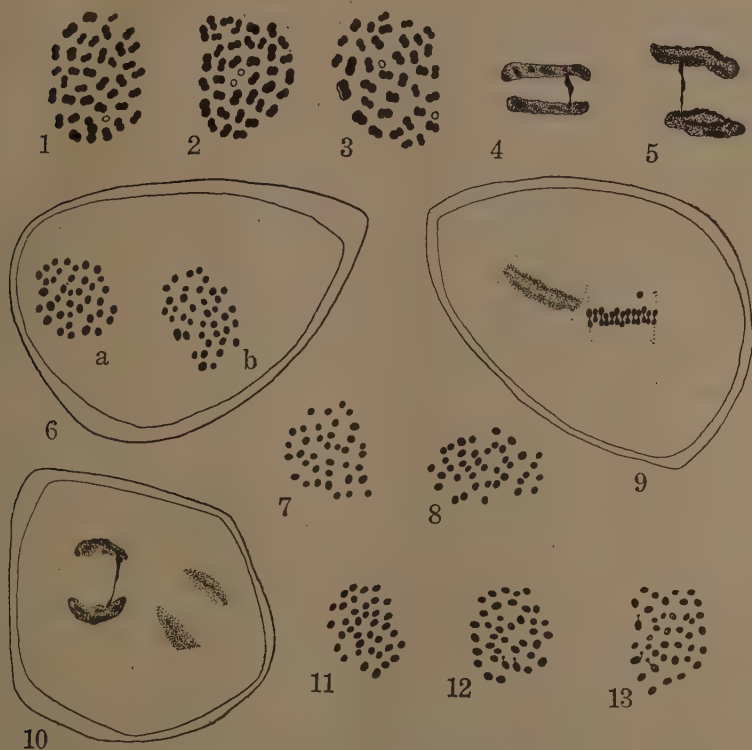
Photo 1. Photomicrograph of a IM of *Carex duvaliana* FRANCH. et SAV., showing a trivalent and a univalent at 6 o'clock.

Acetocarmine preparation.  $\times 1700$ .

TABLE 1. Chromosome configurations at IM of *Carex duvaliana*

Chromosome configuration	Frequency of PMCs
$36_{II}+1_{III}+1_I$ (fig. 1; photo 1)	171 (98.27%)
$37_{II}+2_I$ ( , 2)	2 ( 1.15%)
$35_{II}+1_{IV}+2_I$ ( , 3)	1 ( 0.58%)
Total	174

**IT** Chromosome separation at IT was observed in 363 PMCs and it was normal in 361 PMCs (99.44%). In the resting 2 PMCs, chromosome bridges have been observed, one in each PMC (figs. 4, 5). The bridge in fig. 4 has an appearance of retarded separation of the three associated



Figs. 1-13. The behavior of chromosomes in meiosis of *Carex duvaliana*. 1-3, chromosome associations at IM. 1, the most prevalent configuration,  $36_{II}+1_{III}+1_I$  (cf. photo. 1). 2,  $37_{II}+2_I$ . 3,  $35_{II}+1_{IV}+2_I$ . 4, 5, IT, showing probable retarded separation of a trivalent (4), and bridge (5). 6-9, IIM. 6, sister metaphase plates; a,  $n=38$ ; b,  $n=39$ . 7,  $n=37$ . 8,  $n=40$ . 9, side view of IIM with a divided univalent lying outside the equatorial plate. 10, IIT, with bridge. 11-13, PM; 11,  $n=37$ ; 12,  $n=38$ ; 13,  $n=39$ .  $\times 1900$ .

chromosomes. Therefore the chromosome separation in the IT may be practically considered as normal.

**IIM** The determination of the chromosome number at IIM is important, for the behavior of the trivalent as well as of the univalent in the first division can be conjectured by the frequencies of the chromo-

some numbers at IIM. Chromosomes at IIM have appearances of univalents at IM, rounded in outline, as WAHL (1940) has described, and in the well fixed plates all chromosomes can be seen clearly. Chromosome counts in 118 PMCs are summarized in table 2. All these IIM plates include only such plates in which all elements were distinguished as rounded in outline, and do not include the plates with dubious elements. WAHL (1940), in the behavior of trivalents as well as univalents seen in meiosis of *Carex hirtifolia*, has stated that in polar views of metaphase II there are two types of chromosomes, i.e. normal small chromosomes, rounded in outline, and elongated or irregular elements. He has interpreted that the latter as trivalents (divided equationally in the first division) with two elements arranged side by side and one above or below, indicating a random separation of the elements of a trivalent. In the present case, the efforts to see whether or not the dubious elements mentioned above are of such a type of trivalent, consisting of three elements,

TABLE 2. Chromosome distribution  
at metaphase II

n	Frequency
37	4 ( 3.39%) (fig. 7)
38	57 (48.30%) ( „ 6a)
39	55 (46.61%) ( „ 6b)
40	2 ( 1.70%) ( „ 8)
Total	118

were made, but in vain. Anyhow, the plates with  $n=38$  and  $n=39$  were observed in about the same frequency, and this chromosome distribution at IIM is expected from the alternative disjunction of three elements of a trivalent in the IT. In side view of the metaphase II, sometimes, a small element, rounded in outline and considered as a divided half of the univalent in the first division was seen in the outside of the

equatorial plate (fig. 9). The chromosome distribution in the metaphase II (cf. table 2) shows the split of univalents which has occurred in the first division, and the normal separation of a trivalent, i.e. the alternative disjunction of three elements one by one, that is, two to one pole and one to the other.

**IIT** Chromosome separation in the IIT was observed in 84 PMCs, of which in only one PMC a chromatid bridge was observed (fig. 10) and no sign of lagging was observed. Namely, in 98.81% of PMCs the separation of the chromosomes was normal.

**PM** The primary pollen nuclear division generally takes place immediately after the reduction division in the most species of Cyperaceae. And sometimes the three successive divisions, the first, the second, and the primary pollen nuclear divisions can be seen in one male spike. In the acetocarmine preparations it is rather difficult to get the polar views of the PMs; for the division takes place along the vertical



axis of the cone-shaped pollen. Fortunately, however, 60 PM plates have been observed; of which two quarters (30 PMs) have 38 chromosomes (fig. 12) and 37 and 39 chromosomes were counted in each one quarter of the observed PMs (figs. 11, 13). This distribution of the chromosomes in the PMs is in agreement with the expectation that the all bivalents behaved normally, and that a univalent divided itself in the first division and the halves separated at random to either pole in the second division, and also that a trivalent disjoined alternatively in the first division and their elements separated normally in the second division.

### Discussion

From the observations above described, the behavior of the chromosomes in one plant of *Carex duvaliana* may safely be said to along with the general rule. Namely a univalent present at IM splits in the first division and separates to both poles; the divided elements separate at random in the second division to the poles. Considering the chromosome distribution in the metaphase II and the most prevalent chromosome configuration of  $36_{II}+1_{III}+1_I$  at metaphase I, the following behavior of chromosomes in the first division may be accepted:

At IM the bivalents divide normally and the three elements of a trivalent disjoin alternatively one by one to the poles and also a univalent itself splits. HEILBORN has stated (1928), "The univalents arrange themselves very exactly in the equatorial plane of the heterotypic division and later divide in anaphase. Whether or not they also divide in the homotypic division is uncertain, but such a division seems in fact rather probable; . . .", and recently WAHL (1940) also has described in his paper dealing with *Carex*, "If in cases where univalents are present as a result of asynapsis of homologues (which has been observed in several cases), these split at metaphase II, extra chromosomes would be formed which would then be expected to form multivalent associations in the progeny of the plants in which asynapsis occurred." Could such peculiar behavior of univalents in meiosis take place in the genus *Carex*? In the writer's studies of meiosis of *Carex*, especially of those with structural hybridities, in several cases the retarded division of univalents has been observed in the IT, and it seems most likely that the behavior of univalents belongs to the *Triticum*-type. In the present case, however, such a retarded division of univalents in IT has not been found, and considering the chromosome distribution at metaphase II, the univalent is expected to split in the first division. The successive divisions of univalents at both metaphases I and II, which have been suggested by the authors above mentioned, can scarcely be accepted by the two facts that at first, sometimes, the divided univalents can be seen at the outside of the equatorial plane of the metaphase II in

side view and that in the second, the chromosome distribution at PM is in agreement with the result of random separation of the divided univalents in the second division.

WAHL (1940) has emphasized that in *Carex* all chromosomes split at later IM or at earlier IA, and he has insisted that the first division is equational rather than reductional for all chromosomes. As for the problem whether the first division is equational or reductional, MATSUURA (1938) has reported in meiosis of *Trillium kamtschaticum* that the former mode of separation is as twice as frequent than the latter. HAGA (1937) has confirmed this in *Paris hexaphylla*, and the writer has also observed a similar mode of separation in *Scirpus lacustris* f. *pictus* (TANAKA, 1939a). In these cases, by observing heteromorphic pairing (bivalent chromosomes), the mode of chromosome separation, whether they divide themselves equationally or reductionally, has been determined morphologically. Therefore it may be reasonably assumed that in the first division of *Carex* both these two types of chromosome separations occur together. So, the idea advocated by WAHL that the first division (in *Carex*) is only equational while the second is reductional may deserve critique.

Referring to the separation of multivalents, the cases may somewhat be different. The apparent equational separation of the ring of 6 chromosomes seen in the IM of a hybrid, *Carex swanii* (FERNALD) MACKENZIE  $\times$  *C. gracillima* SCHW., will be the case standing at one extremity (WAHL, 1940), while the reductional separation (alternative separation in zigzag) of the rings of 14 chromosomes in *Oenothera* sp. (CLELAND, 1922 et sq.) or of 12 chromosomes in *Rhoeo discolor* (DARLINGTON, 1929), may be the cases standing at the opposite extremity. Thus the behavior of the multivalent chromosomes in meiosis is far complicated, so the various cases, ranging between these two extremities, must be expected to happen. In the transitional cases the first division is considered in which both modes of separation, reductional as well as equational, take place. Therefore it seems likely that the bridge formation seen at IIT of the present case has originated from either di- or tricentric chromosomes which equationally divided in the first division.

In the last, considering the chromosome configuration at IM,  $36_{II}+1_{III}+1_I$ , it may be said that this plant is an unbalancing trisomic plant with an extra chromosome (mono-trisomic). In no cases has this extra chromosome paired with any other chromosomes, so it seems that it has too far changed in its structural properties to pair with its mate. The structural hybridities seen in the present case suggest the existence of aneuploid plants within this species, *Carex duvaliana*, as well as discovery of the plants with the different degrees of structural hybridities.

### Summary

Chromosome pairing in meiosis of *Carex duvaliana* FRANCH. et SAV. is practically constant, with the configuration of  $36_{II}+1_{III}+1_I$ . An extra univalent chromosome divides itself in the first division and separates at random to the poles in the second division. The components of trivalent disjoin alternatively one by one in the first division.

From the chromosome configurations at IM, the plant used in the present study is considered as a trisomic plant with an extra chromosome.

In conclusion the writer expresses his sincere thanks to Prof. SINOTÔ for his helpful suggestions and valuable advice throughout the course of this work.

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### Literature

- CLELAND, R. E. 1922. The reduction divisions in the pollen mother cells of *Oenothera franciscana*. Amer. Jour. Bot. **9**: 391-413.
- DARLINGTON, C. D. 1929. Chromosome behavior and structural hybridity in the Tradescantiae. Jour. Genet. **21**: 207-286.
- HAGA, T. 1937. Karyotypic polymorphism in *Paris hexaphylla* CHAM., with special reference to its origin and to the meiotic chromosome behavior. Cytologia, FUJII Jub. Vol. 681-700.
- HEILBORN, O. 1928. Chromosome studies in Cyperaceae. Hereditas, **11**: 182-192.
- MATSUURA, H. 1938. Chromosome studies on *Trillium kamschaticum* PALL. VII. Additional evidence for the Neo-two-plane theory of bivalent constitution. Cytologia, **9**: 78-87.
- OKUNO, S. 1940. On the chromosome numbers in the genus *Carex*. Jap. Jour. Genet. **16**: 164-170.
- TANAKA, N. 1939a. Chromosome studies in Cyperaceae, III. The maturation divisions in *Scirpus lacustris* L., with special reference to the heteromorphic pairing. Cytologia, **9**: 533-556.
- 1939b. Ditto, IV. Chromosome number of *Carex* species. Cytologia, **10**: 51-58.
- 1940a. Ditto, VIII. Meiosis in diploid and tetraploid forms of *Carex siderosticta* HANCE. Cytologia, **11**: 282-310.
- 1940b. Ditto, IX. Structural hybridity observed in meiosis of *Carex lanceolata* BOOTT. Bot. Mag. (Tokyo) **54**: 378-388.
- 1940c. Ditto, X. Aneuploid plants of *Carex multifolia* OHWI. Bot. Mag. (Tokyo) **54**: 438-446.
- WAHL, H. A. 1940. Chromosome numbers and meiosis in the genus *Carex*. Amer. Jour. Bot. **27**: 458-470.





# Über die quantitativen Beziehungen zwischen der Katalase in Chloroplasten und dem Chlorophyll, nebst einigen Bemerkungen über die Rolle der Katalase im Assimilationsvorgang

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Mit 16 Tabellen

(Eingegangen am 1. März, 1941)

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## I. Einleitung

Es gibt heute zwei verschiedene Ansichten betreffs des Mechanismus der Photosynthese von grünen Pflanzen. Nach der einen Ansicht sollte man die Herkunft des bei der Assimilation abgegebenen Sauerstoffs auf die Zerlegung des Hydroperoxyds durch Katalase, das im Assimilationsvorgang intermediär auftritt, zurückführen. Hingegen schliesst die andere Ansicht die Wirkung von Katalase auf Hydroperoxyd aus.

Um die erste Ansicht, nach der die Anteilnahme von Katalase im normalen Assimilationsvorgang in Anspruch genommen wird, zu unterstützen, und die Frage, ob das Chlorophyll und die Katalase in enger Beziehung zu einander stehen oder nicht, zu lösen, habe ich einige

Versuche an verschiedenen höheren Pflanzen sowie an verschiedenen Mikroorganismen, Algen und Bakterien, welche durch Photosynthese sein Leben erhalten, angestellt.

## II. Methodisches

Es wurde mit grünen bzw. chlorophylldefekten Blättern von verschiedenen höheren Pflanzen (*Spinacia oleracea*, *Phytolacca esculenta*, *Thea sinensis*, *Paulownia tomentosa*, *Cucurbita maxima*, *Fatsia japonica*, *Brassica oleracea*, *B. japonica*, *Boehmeria japonica*, *Calystegia subvolubilis*, *Osmunda japonica*, *Zebrina pendula*, *Sedum alboroseum*, *Hosta japonica*, *Miscanthus sinensis*, *Saxifraga sarmentosa*, *Vicia Faba*, *Avena sativa*, *Ginkgo biloba* und *Acer palmatum* var. *amabile* u.a.), mit verschiedenen Arten niederer Algen (*Chlorella ellipsoidea*, *Scenedesmus nanus*, *Closterium* sp., *Pleurotaenium* sp., *Pinnularia* sp., *Euglena* sp. und *Oscillatoria* sp. u.a.) und mit einigen Arten der Purpur- bzw. Chlorobakterien (*Rhodobacillus palustris*, *Rhodospirillum giganteum*, *Chromatium minutissimum* und *Chlorobium limicola* u.a.) gearbeitet.

Bei höheren Pflanzen wurden frische, voll entwickelte Blätter, und zwar ca. 10 g davon entnommen. Vor dem jeweiligen Gebrauch wurden die Blätter mit 10-proz. NaCl-Lösung und Sand im Mörser fein zerrieben. Nach der Filtrierung durch feines Seidentuch und anschliessende Abzentrifugierung wurde die grüne Chloroplastenmasse der Untersuchung unterworfen.

Für die Versuche wurden Algen und Bakterien von reinen Stämmen, welche in unserem Laboratorium langjährig fort kultiviert worden sind, gebraucht. Vor dem jeweiligen Gebrauch wurden die Mikroorganismen auch mit 0.9-proz. NaCl-Lösung durch Zentrifugieren zweimal ausgewaschen.

Die Scheidung des Chlorophylls geschah nach der von R. WILLSTÄTTER und A. STOLL<sup>(1)</sup> angegebenen Methode. Die Chlorophyllmenge wurde mittels PULFRICHschen Stufenphotometers bestimmt, wobei Farbenfilter Nr. 4, S. 61 ( $\lambda=6100 \text{ \AA}$ ) verwendet wurde. Die absolute Menge des Chlorophylls wurde aus reinen Krystallen von Äthylchlorophyllid umgerechnet. Obwohl wir gegenwärtig über fein bearbeitete Trennungsmethoden von Chlorophyll *a* und *b* verfügen können, verzichtete ich doch auf ihre Verwendung, da sie zu unserem Zweck keine grösseren Nutzen darbieten dürften als sonst.

Zur Messung der Katalasewirkung wurde die manometrische Methode O. WARBURGS angewandt und der Katalasequotient ( $Q_{\text{Kat.}}$ ) nach A. FUJITA und T. KODAMA<sup>(2)</sup> aus folgender Formel berechnet.

(1) „Untersuchungen über die Assimilation der Kohlensäure“, Berlin, 1918.

(2) Biochem. Ztschr., **232** (1931), 20.

$$Q_{\text{Kat}} = \frac{\text{O}_2\text{-Abgabe in cmm pro 30 Min. bei } 38^\circ}{\text{Trockengewicht (mg)}}$$

### III. Verteilung der Katalase im Blattgewebe

Kürzlich wollte A. C. NEISH<sup>(1)</sup> gelungen haben, die Chloroplasten durch  $\text{CaCl}_2$ -Behandlung aus restlichen Zellsubstanzen des Blattes getrennt zu isolieren. Dieser Forscher hat ferner gefunden<sup>(2)</sup>, dass die Katalase nicht in restlichen Teilen des Zellgebäudes, sondern der Hauptsache nach in Chloroplasten zugegen ist. Diese Tatsache wird umso bemerkenswerter, wenn man es in Betracht ziehen will, dass die Katalase im Assimilationsprozess eine wichtige Rolle spielt.

In meinen eigenen Versuchen, die Katalase in isolierten Chloroplastenmassen und in den restlichen Zellsubstanzen des Blattes einiger höherer Pflanzen quantitativ zu bestimmen, erhielt ich gleiche Ergebnisse wie die NEISHschen. Wie aus Tabelle I ersichtlich, zeigte die isolierte Chloroplastenmasse eine auffallend starke Katalasewirkung, während die übrigen Zellsubstanzen keine wahrnehmbare Wirkung zeigten.

Die Tatsache, dass die Katalase nicht in restlichen Zellbestandteilen, sondern zur Hauptsache in Chloroplasten zu finden ist, macht es wahrscheinlich, dass die Beteiligung der Katalase am Assimilationsprozess denkbar ist.

TABELLE I

Bestimmung des Katalasequotienten in isolierter Chloroplastenmasse bzw. in restlichen Zellsubstanzen des Blattes von verschiedenen Pflanzen.

Pflanzen	Isolierte Chloroplastenmasse		Restliche Zellsubstanzen	
	$Q_{\text{Kat.}}$	Verhältnis von $Q_{\text{Kat.}}$ zum gesamten $Q_{\text{Kat.}}$ von Blattbrei	$Q_{\text{Kat.}}$	Verhältnis von $Q_{\text{Kat.}}$ zum gesamten $Q_{\text{Kat.}}$ von Blattbrei
<i>Spinacia oleracea</i> (1)	82	95.3%	4	4.7%
„ (2)	70	90 %	7	10 %
<i>Brassica japonica</i>	40	97.5%	1	2.5%
<i>Thea sinensis</i>	68	97.2%	2	2.8%

### IV. Verbreitung der Blatt-Katalase in verschiedenen höheren Pflanzen

Um zu sehen, ob die Katalase als Werkzeug von Chloroplasten im Pflanzenreich ubiquitär ist oder nicht, habe ich den Gehalt der Blätter

(1) Biochem. Journ., **33** (1939), 293.

(2) Ebenda, **33** (1939), 300. Vgl. auch G. KROSSING: Biochem. Ztschr., **305** (1940), 359.

an Chloroplastenkatalase verschiedener Pflanzen vergleichend untersucht, indem die durch Filtrieren und Abzentrifugieren aus Blattbrei isolierte Chloroplastenmasse verwandt wurde. Es stellte sich dabei heraus, dass alle untersuchten normalen Blätter ausnahmslos eine deutliche Katalasewirkung zeigen (siehe Tabelle II). Bemerkenswert ist die Tatsache, dass es dabei kein katalasefreies oder katalasearmes Blatt zu finden war. Nach diesen Ergebnissen liegt es nahe, dass die Katalase ganz ubiquitär in Chloroplasten von höheren Pflanzen verbreitet ist.

Ferner wurde die absolute Menge des Chlorophylls in demselben Blatt gemessen in der Hoffnung, etwaige quantitative Beziehung zwischen Katalase- und Chlorophyllgehalt herausfinden zu können. Die Versuchsergebnisse wurden in Tabelle III dargestellt. In Tabelle IV wurde die relative Grösse von Katalase- bzw. Chlorophyllgehalt zum Vergleichszweck angegeben, wobei *Spinacia oleracea* als Standardpflanze angesehen wurde. Wie ersichtlich, laufen der Katalase- und Chlorophyllgehalt immer parallel. Mit anderen Worten zeigten die chlorophyllreichen Blätter immer wieder stärkere Katalasewirkung als die chlorophyllarmen. Der Quotient Katalase/Chlorophyll betrug in allen Fällen stets ungefähr 1.

TABELLE II

Die Katalasewirkung des vollauf entwickelten Blattes verschiedener grüner Pflanzen

Chloroplastenmasse wurde suspendiert in  
M/20 Phosphatpufferlösung (pH 7.2),  
0.2 ccm 0.31 M-H<sub>2</sub>O<sub>2</sub> in Ansatzbirne,

5-proz. KOH im Einsatz.  
Temperatur: 33°.

Pflanzen	Trocken- gewicht (mg)	O <sub>2</sub> -Menge (cmm) pro 30 Min.	Spaltung von H <sub>2</sub> O <sub>2</sub> (%)	Q <sub>Kat.</sub>	
				Mittelwert	
<i>Spinacia oleracea</i>	2.5	180.0	26	72	76
	4.8	384.0	55	80	
<i>Phytolacca esculenta</i>	3.1	170.5	25	55	58
	5.0	305.0	44	61	
<i>Thea sinensis</i>	1.8	120.5	17	67	63.5
	4.9	294.0	42	60	
<i>Paulownia tomentosa</i>	3.4	153.0	22	45	44
	7.2	309.5	45	43	
<i>Cucurbita maxima</i>	2.9	139.0	20	48	49
	5.5	275.0	40	50	
<i>Fatsia japonica</i>	4.1	155.0	22	38	37.5
	7.3	270.0	39	37	
<i>Brassica japonica</i>	2.2	83.5	12	38	39
	6.6	264.0	38	40	
<i>Brassica oleacea</i>	2.8	73.0	11	26	24
	5.5	121.0	17	22	
<i>Boehmeria japonica</i>	4.0	284.0	41	71	71
	8.6	610.5	88	71	
<i>Calystegia subvolubilis</i>	3.8	159.5	23	42	46
	7.0	350.0	50	50	
<i>Osmunda japonica</i>	2.7	143.0	21	53	57
	6.4	390.5	56	61	



TABELLE III

Der Chlorophyllgehalt des vollauf entwickelten Blattes verschiedener grüner Pflanzen.

Pflanzen	Trockengewicht (mg)	Chlorophyllmenge	
		(mg)	%
<i>Spinacia oleracea</i>	99	1.148	1.15
<i>Phytolacca esculenta</i>	120	1.104	0.92
<i>Thea sinensis</i>	164	1.607	0.99
<i>Paulownia tomentosa</i>	119	0.964	0.89
<i>Cucurbita maxima</i>	85	0.723	0.85
<i>Fatsia japonica</i>	154	1.063	0.68
<i>Brassica oleracea</i>	105	0.347	0.33
<i>B. japonica</i>	90	0.378	0.42
<i>Boehmeria japonica</i>	201	2.090	1.04
<i>Calystegia subvolubilis</i>	97	0.718	0.74
<i>Osmunda japonica</i>	82	0.631	0.77

TABELLE IV

Pflanzen	Relative Grösse der Katalasewirkung (umgerechnet aus Tab. II)	Relative Grösse des Chlorophyllgehaltes (umgerechnet aus Tab. III)	Quotient Kat./Chl.
<i>Spinacia oleracea</i>	100	100	1
<i>Phytolacca esculenta</i>	76.3	81.9	0.93
<i>Thea sinensis</i>	83.5	84.5	0.99
<i>Paulownia tomentosa</i>	57.8	69.8	0.83
<i>Cucurbita maxima</i>	64.4	73.3	0.88
<i>Fatsia japonica</i>	49.3	59.5	0.83
<i>Brassica oleracea</i>	31.3	28.5	1.10
<i>B. japonica</i>	93.4	89.6	1.04
<i>Calystegia subvolubilis</i>	60.5	63.8	0.95
<i>Osmunda japonica</i>	75.0	66.4	1.13

## V. Vorkommen der Katalase in verschiedenen photosynthetisch tätigen Mikroorganismen

Um zu konstatieren, ob die Katalase in Zellgefügen von Mikroorganismen, die mit dem Assimilationspigment versehen und photosynthetisch tätig sind, ubiquitär vorkommt oder nicht, habe ich ferner eine Reihe von Versuchen angestellt, wobei ich verschiedene Algen, z. B.

*Chlorella ellipsoidea*, *Scenedesmus nanus* (Grünalgen), *Closterium* sp., *Pleurotaenium* sp. (Conjugatae), *Pinnularia* sp. (Diatomae), *Euglena viridis* (Flagellatae) und *Oscillatoria* sp. (Blaualge) u. a. und farbige Bakterien z. B. *Rhodobacillus palustris*, *Rhodospirillum giganteum*, *Chromatium minutissimum*, *Chlorobium limicola* gebraucht wurden.

Die Versuchsergebnisse wurden in Tabelle V zusammengestellt, und man ersieht hiervon das allgemeine Vorkommen der Katalase in jedem der untersuchten Mikroorganismen, und zwar so deutlich, wie es bei höheren grünen Pflanzen der Fall ist. Wie ich in früheren Ausführungen<sup>(1)</sup> mitgeteilt habe, gibt es unter niederen Algen sowie Purpurbakterien, die in schwefelwasserstoffhaltigen Medien (schwefelwasserstoffhaltigem Wasser, Schwefelthermen u.a.) leben, einige Arten, bei denen Kohlensäure-Assimilation ohne Mitwirkung der Katalase stattfindet, weil der Schwefelwasserstoff, der als spezifisches Katalasegift bekannt ist, in deren photosynthetischem Reaktionsmechanismus miteinbegriffen werden kann. Beachtenswert ist die Tatsache, dass diese Algen bzw. Bakterien noch einen grossen Katalasegehalt zeigen, wenn die Katalase in Schwefelwasserstoff ihre Wirkung verloren hat. Man kann vermuten, dass die durch die Katalase bedingte Photosynthese bei oben angeführten Organismen ebenfalls normal ist, und dass die Schwefelwasserstoff bedürftige Photosynthese eine abnorme ist, da sie vielleicht eine Folge der Anpassung an die Umgebung sei, in der die betreffenden Organismen leben.

Aus oben erwähntem Tatbestand kann man darauf schliessen, dass die Mikroorganismen, die mit Assimilationspigment, wie Chlorophyll, Bakteriochlorophyll sowie Bakterioviridin u. a., versehen sind, ausnahmslos eine nicht unbedeutende Menge von Katalase enthalten.

TABELLE V

Vorkommen von Katalase bei verschiedenen Mikroorganismen, die photosynthetisch leben.

Pflanzen	Assimilationspigment	Katalasequotient Q <sub>Kat.</sub>
<i>Chlorella ellipsoidea</i>	Chlorophyll	64
<i>Scenedesmus nanus</i>	"	75
<i>Closterium Ehrenbergii</i>	"	88
<i>Pleurotaenium</i> sp.	"	65
<i>Pinnularia</i> sp.	"	42
<i>Euglena viridis</i>	"	40
<i>Oscillatoria</i> sp.	"	29
<i>Rhodobacillus palustris</i>	Bakteriochlorophyll	82
<i>Rhodospirillum giganteum</i>	"	105
<i>Chromatium minutissimum</i>	"	86
<i>Chlorobium limicola</i>	Bakterioviridin	50

(1) H. NAKAMURA: Bot. Mag. (Tokyo), 51 (1937), 529; Acta Phytochim., 10 (1938), 271.

## VI. Katalasegehalt von Chlorophylldefekten Blättern

Vor einem Jahrzehnt haben v. EULER<sup>(1)</sup> und seine Mitarbeiter über die Chemie der chlorophylldefekten Blätter vielfach gearbeitet und mitgeteilt, dass ein vollständiger oder annähernd vollständiger Chlorophylldefekt stets von einem sehr starken Katalase-Defizit begleitet ist.

Meine eigenen Versuche, worin etwa 20 chlorophylldefekte Arten untersucht wurden, zeigten Ergebnisse, die ganz analog ausfielen, d.h., der Katalasegehalt bei chlorophylldefekten, also weissen Blättern zeigte

TABELLE VI

Vergleich zwischen den Katalasegehalten von normalem und chlorophylldefektem Blatt.

Versuchsanordnung wie in Tabelle II.

Pflanzen	Farbe des Blattes	Trocken- gewicht (mg)	O <sub>2</sub> -Menge (cmm) pro 30 Min., 38°	Spaltung von H <sub>2</sub> O <sub>2</sub> (%)	Q <sub>Kat.</sub>	
					Mittelwert	
<i>Zebrina pendula</i>	grün	4.8	297.5	43	62	64.5
	"	9.9	663.0	95	67	
	weiss	5.5	49.5	7	9	10
	"	9.5	104.5	15	11	
<i>Sedum alboroseum</i>	grün	2.8	106.0	15	38	35
	"	11.2	358.0	52	32	
	weiss	4.2	8.0	1	2	3
	"	9.7	39.0	6	4	
Albinomutant von <i>Hosta japonica</i>	grün	3.3	148.5	21	45	42
	"	8.5	331.5	48	39	
	weiss	2.9	17.4	3	6	5.5
	"	8.9	44.5	6	5	
Albinomutant von <i>Fatsia japonica</i>	grün	4.8	211.0	30	44	42
	"	9.6	384.0	55	40	
	weiss	5.2	26.0	4	5	4
	"	10.6	32.0	5	3	
Albinomutant von <i>Miscanthus sinensis</i>	grün	1.5	78.0	11	52	49
	"	6.9	317.0	46	46	
	weiss	2.0	4.0	1	2	3.5
	"	7.7	33.5	6	5	
Albinomutant von <i>Saxifraga sarmentosa</i>	grün	4.4	251.0	36	57	57
	"	10.0	570.0	82	57	
	weiss	5.1	35.5	5	7	7.5
	"	9.9	79.0	11	8	

(1) H. v. EULER u. H. HELLSTRÖM: Ztschr. f. physiol. Chem., **182** (1929), 205; ebenda, **183** (1929), 113; H. v. EULER u. D. RUNEHJELM: ebenda. **185** (1929), 74.

sich ausnahmslos beträchtlich kleiner als bei chlorophyllnormalen grünen Blättern (siehe Tabelle VI u. VII). Die Vergleichung der relativen Grösse von Katalase- bzw. Chlorophyllgehalt bei den chlorophyllnormalen bzw.

TABELLE VII  
Vergleich von Chlorophyllgehalt zwischen dem normalen  
und chlorophyll defekten Blatt.

Pflanzen	Farbe des Blattes	Trocken- gewicht (mg)	Chlorophyllgehalt	
			(mg)	(%)
<i>Zebrina pendula</i>	grün	134	1.085	0.81
	weiss	225	0.025	0.01
<i>Sedum alboroseum</i>	grün	201	1.106	0.55
	weiss	244	0.488	0.20
Albinomutant von <i>Hosta japonica</i>	grün	114	0.707	0.62
	weiss	250	0.018	0.01
Albinomutant von <i>Fatsia japonica</i>	grün	232	1.253	0.54
	weiss	268	0	0
Albinomutant von <i>Miscanthus sinensis</i>	grün	109	0.447	0.41
	weiss	305	0.018	0.01
Albinomutant von <i>Saxifraga sarmentosa</i>	grün	225	1.418	0.63
	weiss	307	0.040	0.01

TABELLE VIII

Pflanzen	Farbe des Blattes	Relativer Wert der Katalasegehalt (umgerechnet aus Tab. VI)	Relativer Wert der Chlorophyllmenge (umgerechnet aus Tab. VII)
<i>Zebrina pendula</i>	grün	100	100
	weiss	15.5	0.012
<i>Sedum alboroseum</i>	grün	100	100
	weiss	8.5	0.363
Albinomutant von <i>Hosta japonica</i>	grün	100	100
	weiss	13.1	0.112
Albinomutant von <i>Fatsia japonica</i>	grün	100	100
	weiss	9.5	0
Albinomutant von <i>Miscanthus sinensis</i>	grün	100	100
	weiss	7.1	0.014
Albinomutant von <i>Saxifraga sarmentosa</i>	grün	100	100
	weiss	13.1	0.020

chlorophylldefekten Blättern wurde in Tabelle VIII dargestellt, wobei die der chlorophyllnormalen Blätter als Standard angesehen wurden. Wie



daraus ersichtlich, wurde die Parallelität zwischen Katalase- und Chlorophyllgehalt gefunden.

Die Versuche mit etiolierten Blättern der Gerste bzw. Pferdebohne sind in Tabelle IX dargestellt, wobei stets die 6-tägigen Keimlinge, die in Blechkästen zwischen Filtrierpapier, welches durch mehrmaligen täglichen Wasserzusatz zu konstanter Feuchtigkeit gehalten wurde, zur Untersuchung verwandt wurden. Wie daraus ersichtlich, war eine gegenseitige Beziehung zwischen Katalase- bzw. Chlorophyllgehalt ganz wie bei Albinomutanten stets der Fall, d.h., die etiolierten also gelben Blätter sind stets von einem sehr starken Katalase-Defizit begleitet.

## VII. Vergleichung von Tageslicht- mit Schattenzellen einiger Algen betreffs Katalase- sowie Chlorophyllgehaltes

Wie man kennt, ist der Chlorophyllgehalt von in direktem Tageslicht gezüchteten grünen Algen stets kleiner als der von in Schatten gezüchteten. Um den Katalasegehalt von Tageslichtzellen bzw. Schattenzellen der Algen vergleichend zu untersuchen, wurde ferner ein Versuch angestellt, indem der Chlorophyllgehalt im besonderen berücksichtigt wurde.

Wie man aus der Tabelle X zu ersehen ist, ist der Katalasegehalt der Schattenzellen von *Chlorella* bzw. von *Scenedesmus* stets grösser als der der Tageslichtzellen.

Es wird also damit als konstatiert angesehen, dass der Katalasegehalt von der Menge des Chlorophylls abhängig ist.

TABELLE IX

Vergleich des Katalasegehaltes von Tageslicht- bzw. Schattenzellen einiger Algen.

Arten	Tageslichtzellen				Schattenzellen			
	Chlorophyll (%)		Q <sub>Kat.</sub>		Chlorophyll (%)		Q <sub>Kat.</sub>	
<i>Chlorella ellipsoidea</i>	2.2	2.5	32	62	3.5	4.0	54	70
<i>Scenedesmus nanus</i>	2.4	2.8	40	65	3.2	3.7	61	84

## VIII. Katalase- bzw. Chlorophyll-Bildung in etiolierten Blättern

Betreffs der Bildung der Chloroplastenfarbstoffe und ihrer Beziehungen zueinander liegen schon eine grössere Anzahl Arbeiten vor<sup>(1)</sup>.

(1) Vergl. z. B. H. v. EULER u. H. HELLSTRÖM: Ztschr. f. physiol. Chem., **183** (1929), 177; J. D. GUTHRIE: Amer. Journ. Bot., **16** (1929), 716; CH. SHEARD, HIGGINS, FORSTER: Ref. Ber. Biol., **14** (1930), 832; W. SCHARFNAGEL: Planta, **13** (1931), 716; H. RUDOLPH: Ebenda, **21** (1934), 104.

Im Anschluss an die bisherigen Ausführungen über die Entstehung des Chlorophylls sei noch kurz bemerkt, dass vielleicht auch noch andere Stoffe, wie z. B. Peroxydase und Katalase, am Aufbau dieses Farbstoffes mitbeteiligt sein könnten. In Bezug auf Peroxydase hat V. N. LUBIMENKO Beziehungen zwischen dieser und dem Chlorophyll festgestellt<sup>(1)</sup>. Nach ihm ändert sich die Farbstoffmenge mit der Menge der freien Peroxydase. Beim Anstieg des Peroxydasegehaltes steigt auch die Chlorophyllbildung an. Gleichzeitig tritt beim Sinken der Peroxydasemenge ein Verlust an Chlorophyll ein. Bei weiterer Verminderung der Peroxydase soll nach LUBIMENKO sich die Bildung der gelben Pigmente vollziehen.

Quantitative Beziehungen zwischen Katalase und Chlorophyll ebenso wie zwischen Katalase- und Carotinoidgehalt wurden von v. EULER gefunden. Bei der Keimung erscheint die Katalase vor dem Auftreten dieser Farbstoffe. Eingehende Untersuchungen über die Wirkungsweise der genannten Stoffe bei der Farbstoffbildung oder -umbildung sind bisher nicht ausgeführt worden.

Bekanntlich entsteht das Chlorophyll ausser bei einigen Kryptogamen und Keimpflanzen von Koniferen nur in Gegenwart vom Licht. Mit anderen Worten ist die Synthese des Chlorophylls bei höheren Pflanzen ganz und gar vom Licht abhängig. Die Lichtmenge, die für die Chlorophyllsynthese notwendig ist, ist indessen sehr gering. Schon nach einigen Sekunden Belichtung von etiolierten Pflanzen konnte Chlorophyll in diesen spektroskopisch nachgewiesen werden.

Um die mengenmässigen Verhältnisse der Katalase bei der Chlorophyllsynthese zu konstatieren, habe ich ferner einige Versuche angestellt. Als Versuchsmaterial wurden eitolierte Blätter des Hafers, *Avena sativa*, und von Pferdebohne, *Vicia Faba*, gewählt. Die Keimung erfolgte in Blechkästen in der Dunkelkammer zwischen Filtrierpapier, welches durch mehrmaligen täglichen Wasserzusatz bei konstanter Feuchtigkeit gehalten wurde.

Zur zeitlichen Bestimmung wurden je 20 Pflänzchen angewandt, die in 6 Tagen nach Keimung in der Dunkelkammer gewachsen waren.

Wie aus Tabellen X, XI und XII hervorgeht, nahm der Katalasegehalt der etiolierten Blätter bei den Versuchspflanzen nach ziemlich kurzer Belichtung auffallend zu.

Es ist also wahrscheinlich, dass die durch Bestrahlung erbrachte Anreicherung der Katalase mit Chlorophyllbildung in engster Beziehung steht. Obige Tatsache dürfte darauf hindeuten, dass nicht nur die Chlorophyll-, sondern auch die Katalasebildung in der Pflanze eine vom Licht abhängige Reaktion sei. Die Synthese von beiden Stoffen, Chloro-

(1) Ztschr. indukt. Abst.- u. Vererb.-Lehre, 2 (1938), 1058; Rev. gén. Bot., 38 (1926).

phyll und Katalase, scheint mir keine zufällige Erscheinung zu sein, umso mehr als man es in Betracht zieht, dass die beiden Substanzen Porphyrinderivate sind. Dementsprechend haben v. EULER<sup>(1)</sup> u.a. erörtert, dass die Anwesenheit von Katalase in Chromatophoren eine Voraussetzung für die Chlorophyllbildung ist, und dass sich die beiden Stoffe nebeneinander auf chemischen Entwicklungslinien bilden, welche auf einen gemeinsamen Stamm zurückgehen; in diesem haben sie die Porphyrinbildung angenommen, sowie die Bildung der in das Phytol und in die Carotinoide eingehenden Isoprenreste.

TABELLE X

Chlorophyllbildung bei etiolierten Keimblättern von *Avena* durch Bestrahlung.

Belichtungszeit in Stdn.	Farbe des Keimblattes	Trockengewicht (mg)	Chlorophyllmenge	
			(mg)	(%)
Anfang	gelb	711	0	0
2	"	706	0.028	0.003
5	gelbgrün	654	0.216	0.033
8	hellgrün	541	0.568	0.104
10	"	500	0.700	0.14
12	"	488	0.893	0.183
14	grün	529	1.032	0.195
16	"	550	1.128	0.205
20	"	632	1.327	0.209

TABELLE XI

Katalase-Bildung bei etiolierten Keimblättern von *Avena* durch Bestrahlung.

Belichtungszeit in Stdn.	Farbe des Keimblattes	Trockengewicht (mg)	Q <sub>Kat.</sub>
Anfang	gelb	10.5	1.3
2	"	8.1	1.3
5	gelbgrün	7.5	1.6
7	"	7.7	4.7
10	hellgrün	6.8	14.3
12	"	8.5	19.7
14	grün	7.6	23.0
16	"	5.5	27.9
20	"	9.1	31.0

(1) Loc. cit.

TABELLE XII

Belichtungszeit in Stdn.	Relative Grösse von	
	Chlorophyllgehalt	Katalasegehalt
Anfang	0	4.2
2	2	4.2
5	15.5	5.0
8	50.0	15.2
10	66.5	46.0
12	87.0	63.4
14	93.0	74.1
16	97.5	90.0
20	100	100

TABELLE XIII

Vergleich der relativen Grösse von Chlorophyll- bzw.  
Katalase-Gehalt bei *Vicia Faba*.

Belichtungszeit in Stdn.	Relative Grösse von	
	Chlorophyllgehalt	Katalasegehalt
Anfang	0	9.1
2	6.2	11.2
4	27.2	13.4
6	68.7	31.5
10	89.4	49.7
12	95.1	64.4
14	100	100

### IX. Katalase- bzw. Chlorophyllzersetzung bei herbstlichen Blättern

Wie R. WILLSTÄTTER<sup>(1)</sup> u. a. nachgewiesen haben, ist es allgemein bekannt, dass das Gelbwerden und zum Teil auch Rotwerden der herbstlichen Blätter auf die Zersetzung des Chlorophylls zurückzuführen ist. Hinsichtlich der Ursache und des Vorgangs des Verschwindens von Chlorophyll herrscht aber heute noch eine Dunkelheit.

Um die Veränderung des Katalasegehaltes bei den nekrobiotischen herbstlichen Blättern zu bestimmen, habe ich weiter eine Reihe von Unter-

(1) R. WILLSTÄTTER u. A. STOLL: „Untersuchungen über die Assimilation der Kohlensäure“, Berlin, 1918.

suchungen gemacht. Wie SJÖBERG<sup>(1)</sup> u. a. berichtet haben, tritt die enzymatische Aktivität im Herbst sicherlich zurück.

Als Versuchsmaterial wurden ein Ginkgobaum, *Ginkgo biloba*, der sich seine Blätter im späten Herbst gelb färbt, und ein Ahorn, *Acer*

TABELLE XIV (a)

Herbstliche Zersetzung von Chlorophyll bzw. Katalase bei einigen Herbstblättern.

Zeit in Tagen	<i>Ginkgo biloba</i>											
	Nr. 1				Nr. 2				Nr. 3			
	Chlorophyll		Katalase		Chlorophyll		Katalase		Chlorophyll		Katalase	
	mg	Relative Grösse	Q <sub>Kat.</sub>	Relative Grösse	mg	Relative Grösse	Q <sub>Kat.</sub>	Relative Grösse	mg	Relative Grösse	Q <sub>Kat.</sub>	Relative Grösse
Anfang (d. 22. Okt. 1938)	0.561	100	52	100	0.601	100	45	100	0.295	100	41	100
2 (d. 24. „ )	—	—	48	92.3	—	—	44	97.7	—	—	41	100
4 (d. 26. „ )	0.201	35.8	37	71.2	0.330	54.8	45	100	0.037	12.5	39	95.1
6 (d. 28. „ )	—	—	36	69.2	—	—	40	88.9	—	—	34	82.9
8 (d. 30. „ )	0.087	15.5	31	59.6	0.008	1.3	39	86.6	0.002	0.7	26	63.4
10 (d. 1. Nov. 1938)	—	—	30	57.7	—	—	33	73.3	—	—	18	43.9
12 (d. 3. „ )	0.004	0.7	25	48.1	0	0	35	77.7	0	0	16	39.0
14 (d. 5. „ )	—	—	14	26.9	—	—	31	68.8	—	—	15	36.6
16 (d. 7. „ )	0	0	12	23.1	0	0	29	64.4	0	0	13	31.7

TABELLE XIV (b)

Zeit in Tagen	<i>Acer palmatum</i> var. <i>amabile</i>											
	Nr. 1				Nr. 2				Nr. 3			
	Chlorophyll*		Katalase		Chlorophyll*		Katalase		Chlorophyll*		Katalase	
	mg	Relative Grösse	Q <sub>Kat.</sub>	Relative Grösse	mg	Relative Grösse	Q <sub>Kat.</sub>	Relative Grösse	mg	Relative Grösse	Q <sub>Kat.</sub>	Relative Grösse
Anfang (d. 23. Okt. 1938)	0.701	100	72	100	0.690	100	68	100	0.721	100	61	100
4 (d. 27. „ )	0.573	81.7	61	82.6	0.225	32.6	46	67.6	0.426	59.1	50	82.0
8 (d. 31. „ )	0.038	12.6	54	75.0	0.019	2.8	26	38.2	0.200	27.7	33	54.1
12 (d. 4. Nov. 1933)	0.001	0.1	19	26.5	0	0	7	10.3	0.022	3.2	20	32.8

\* Chlorophyllmenge auf 100 mg Blatt (Trockengewicht) gerechnet.



*palmatum* var. *amabile*, der im Herbst seine Blätter rot färbt, gewählt. Die Versuche wurden in einem Zeitabschnitt vom Ende Oktober bis Anfang November 1938 ausgeführt.

Die quantitative Veränderung des Katalase- bzw. Chlorophyllgehaltes wurde zeitlich verfolgt.

Die Versuchsergebnisse stehen in Tabellen XIV u. XV. Wie daraus ersichtlich, wurde eine beträchtliche Katalase-Verminderung bei nekrobiotischen herbstlichen Blättern beobachtet. Also kann man vermuten, dass diese Verminderung des Katalasegehaltes mit dem Sinken des Chlorophylls in Beziehung steht.

### X. Bemerkungen über die Rolle der Katalase im Assimilationsvorgang

Wie oben näher auseinandergesetzt wurde, enthalten photosynthetisch tätige Pflanzen ausnahmslos bedeutende Menge von Katalase, und zwar geht ihr Gehalt der Chlorophyllmenge ganz parallel. Ich konnte keine katalasefreien oder -armen Pflanzen finden, die im Besitz des Assimilationspigments und deshalb assimilationsfähig sind.

Über die Rolle der Katalase in der normalen Photosynthese wurde schon vielfach diskutiert. Namentlich steht die Assimilationstheorie von SHIBATA<sup>(1)</sup> im Vordergrund, welche die photochemische Entstehung des Hydroperoxyds aus den an Chlorophyll koordinierten Wassermolekülen und von Katalase katalysierten Zerfall des Hydroperoxyds in Dunkelreaktion unter Abgabe von Sauerstoff voraussetzt. Dazu hat YAKUSHIJI die Rolle der Katalase im Reaktionsprozess der Photosynthese von einigen Algen untersucht und festgestellt, dass die Photosynthese durch Substanzen, die spezifisch auf Katalase vergiftend einwirken, ausnahmslos weitgehend gehemmt wurde<sup>(2)</sup>. Bei Purpurbakterien habe ich ebenfalls konstatiert, dass die normale bakterielle Photosynthese durch Katalasegift stets gehemmt wurde, wie es auch bei grünen Pflanzen der Fall ist (vergl. Tabellen XVI u. XVII).

Im Gegensatz zu dieser Katalase-Theorie liegen aber natürlich andere Meinungen vor. Einige Autoren, z. B. VAN DER PAAUW, EMERSON, GAFFRON u. a., behaupten, dass die Photosynthese durch Zusatz von Katalasegift, wie Blausäure, nur wenig beeinflusst wird. VAN DER PAAUW<sup>(3)</sup> und EMERSON<sup>(4)</sup> haben bei *Hormidium* mitgeteilt, dass die Photosynthese dieser Alge durch Zusatz von Blausäure nur wenig beein-

(1) Vergl. K. SHIBATA u. E. YAKUSHIJI: Naturwiss., **21** (1933), 267.

(2) E. YAKUSHIJI: Acta Phytochim., **7** (1933), 93.

(3) VAN DER PAAUW: Rec. trav. bot. Néérl., **29** (1932), 497.

(4) R. EMERSON: Ergeb. d. Enzymforsch., **5** (1936), 305.

flusst wird. GAFFRON<sup>(1)</sup> hat neulich auch mitgeteilt, dass die Photosynthese von *Scenedesmus* nur geringe Empfindlichkeit gegen Blausäure zeigte. Im Gegensatz zu GAFFRON habe ich aber festgestellt, dass die Photosynthese von *Scenedesmus nanus* gegen Blausäure sehr empfindlich ist, wie es bei anderen grünen Algen stets der Fall ist. Seinen Versuchen entsprechend hat GAFFRON die Meinung veröffentlicht, dass auffallende Unterschiede nicht nur von verschiedenen Algenarten (wie *Chlorella*, *Scenedesmus*, *Hormidium* u. s. w.) gezeigt wurden, sondern auch von morphologisch gleich aussehenden Stämmen derselben Art gezeigt wurde.

Andererseits wurde es von VAN HILLE u. a. erörtert<sup>(2)</sup>, dass alte Algenkulturen kleine Assimilationsfähigkeit zeigen, während die Katalaseaktivität noch stark ist. Aus diesem Grunde behauptete er, dass die Katalasewirkung mit der Assimilation nicht zu tun hat. Das ist aber nicht zutreffend, und zwar deshalb, weil die Katalase nicht nur im Assimilationsvorgang, sondern gewiss auch teilweise im Atmungsvorgang mitwirkt.

Neulich hat K. NOACK mitgeteilt, dass die Alge *Chlorella* keinen Sauerstoff im Lichte abspaltet, wenn sie lange Zeit im Dunkeln gestanden hat, und zwar deshalb, weil inzwischen saure Substanz im Medium gebildet wird und die Reaktion zu sauer wird. Die Assimilationsfähigkeit ( $O_2$ -Abgabe) kann durch Neutralisation wiederhergestellt werden. Diese Tatsache stimmt damit überein, dass die Katalasewirkung in saurem Medium beträchtlich herabgedrückt wird.

H. GAFFRON<sup>(3)</sup> hat neulich eine Angabe gemacht, dass ein Peroxyd, dass nach diesem Autor nicht identisch mit Hydroperoxyd ist, im Assimilationsvorgang intermediär gebildet wird und dass unter Mitwirkung eines der Katalase ähnlichen Enzyms abgespalten wird. Es ist aber kaum begreiflich, warum dieses katalaseähnliche Enzym gegen Blausäure so stabil sein kann.

TABELLE XV

Wirkung von Hydroxylamin auf die Photosynthese.

Pflanzen	Mol.	Hemmung von Photosynthese	Forscher
<i>Chlorella</i>	M/9000	—100	YAKUSHIJI
<i>Scenedesmus</i>	M/10000	—95	NAKAMURA
<i>Fontinalis</i>	M/1000	—100	USAMI
<i>Rhodobacillus</i>	M/2000	—100	NAKAMURA

(1) H. GAFFRON: Biol. Ztribl., **59** (1939), 288.(2) J. C. VAN HILLE: Rec. trav. bot. Néerl., **35** (1938), 680.(3) Nature, **143** (1939), 204.

TABELLE XVI  
Wirkung von Blausäure auf die Photosynthese.

Pflanzen	Mol.	Hemmung von Photosynthese	Forscher
<i>Chlorella</i>	M/10000	-55	WARBURG, EMERSON
<i>Stichococcus</i>	"	-40	VAN DER PAAUW
<i>Gigartina</i>	"	-60	EMERSON u. GREEN
<i>Nischia closterium</i>	"	-100	GAFFRON
<i>Hormidium</i>	"	+10 bis -15	VAN DER PAAUW
<i>Scenedesmus basiliensis</i>	"	0 bis -20	GAFFRON
<i>S. nanus</i>	"	-78	NAKAMURA
<i>Oscillatoria</i>	"	-60	NAKAMURA
<i>Pinnularia</i>	"	-85	NAKAMURA
<i>Rhodobacillus</i>	"	-100	NAKAMURA
<i>Chromatium</i>	"	-100	NAKAMURA

## XI. Zusammenfassung

1) An Hand verschiedener höherer bzw. niederer Pflanzen werden die quantitativen Beziehungen zwischen Katalase- und Chlorophyllmenge untersucht und folgende Tatsachen festgestellt.

2) Im Blatt kommt die Katalase hauptsächlich in Chloroplasten vor; in anderen Geweben ist sie nur spärlich zu finden.

3) Alle untersuchten chlorophyllnormalen Blätter zeigen ausnahmslos eine deutliche Katalasewirkung.

4) Die Katalase kommt ausnahmslos und zwar deutlich in allen untersuchten Mikroorganismen, Algen und Bakterien, vor, die zur Photosynthese befähigt sind.

5) Alle chlorophylldefekten Blätter sind mit starker Katalaseverminderung begleitet.

6) Bei Tageslicht- bzw. Schattenzellen einiger Algen wird eine Parallelität zwischen Katalase- und Chlorophyllmenge beobachtet.

7) Die Katalase- bzw. Chlorophyll-Bildung geschieht immer parallel.

8) Die Katalase- bzw. Chlorophyll-Zersetzung in herbstlichen nekrobiotischen Blättern läuft auch immer parallel.

9) Die Rolle der Katalase im Assimilationsvorgang wird eingehend erörtert.

## ABSTRACTS

EXPLANATION OF ABBREVIATIONS OF THE JOURNALS' NAMES  
REFERRED IN THE ABSTRACTS CONTAINED IN THIS NO.

<i>Abbreviations</i>	<i>Names of Journals</i>
A.H.	Agriculture and Horticulture (農業及園藝)
A.P.	Acta Phytochimica
A.P.P.S.J.	Annals of the Phytopathological Society of Japan (日本植物病理學會報)
B.I.S.E.S.T.	Bulletin of the Imperial Sericultural Experiment Station, Tokyo (蠶絲試驗場報告)
B.M.T.	The Botanical Magazine, Tôkyô (植物學雜誌)
B.Z.	Botany and Zoology (植物及動物)
Cyt.	Cytologia
E.R.	Ecological Review (生態學研究)
Jap.J.B.	Japanese Journal of Botany
J.Jap.B.	Journal of Japanese Botany (植物研究雜誌)
J.J.G.	Japanese Journal of Genetics (遺傳學雜誌)
J.S., H.U.	Journal of Science, Hiroshima University
M.C.A., K.I.U.	Memoirs of the College of Agriculture, Kyoto Imperial University
P.C.S.S.J.	Proceedings of the Crop Science Society of Japan (日本作物學會記事)
P.I.A.	Proceedings of the Imperial Academy
R.B., T.I.S.C.	Research Bulletin of the Tokyo Imperial Sericultural College (東京商等蠶絲學校研究報告)
S.B.A.E.S., O.P.	Special Bulletin, Agricultural Experiment Station, Okayama Prefecture (岡山縣立農事試驗場臨時報告)
Sc. Rpts., T.B.R.D.	Science Reports of the Tokyo Bunrika Daigaku, Section B
Sc. Rpts., T.I.U.	Science Reports, Tôhoku Imperial University, Section IV
T.S.N.H.S.	Transactions of the Sapporo Natural History Society (札幌博物學會報)





## Abstracts Nos. 147-272

(Referring mostly to the principal papers in Botany and allied subjects which have appeared in Japan during January-June 1940)

**147. Abnormal meiosis in genus *Hosta* (A preliminary note).** (Japanese with English résumé). Toshio AKEMINE. (J.J.G. **16**, 1940, 13-16, 27 text-figs.).

Species of the genus *Hosta* containing  $2n=60$  are generally characterized by their regular reducing divisions. In *H. undulata* BAILEY the author has seen a very conspicuous irregularity of meiotic behavior in I-metaphase and diakinesis of PMCs, all of which behaved very abnormally without any single exception. One of the most frequent anomalies is the formation of the univalents, which are often so numerous as shown by the extreme cases,  $13_{II}+34_I$  or  $19_{II}+22_I$ . The fragmentation of chromosomes takes place very frequently. Tri- or tetravalents were also observed, which might be the result of reciprocal translocation. Besides, the bivalents associated only terminally were met with. As the consequence of such irregularities a number of aberrations have taken place in later stages, such as the occurrence of lagging chromosomes, fragments, chromatin bridges, etc. The cytokinesis was however quite regular, so that no microcytes were produced at the tetrad stages. Pollen is completely sterile and no seeds at all were produced.

**148. On the systematic anatomy of the leaves of some Japanese *Carex*. XXVIII.** (Japanese with English résumé). Shigeo AKIYAMA. (B.M.T. **54**, 1940, 130-135, 3 text-figs.-groups).

This paper is the continuation of the author's extensive anatomico-systematic study of the leaves of some Japanese *Carex* species. *Carex aequialta*, *C. aphyllopus*, and *C. caespitosa*, all of which belong to the section *Acutae*, are contained in this paper.

**149. Notes on the Japanese *Carex* (VI)-(VII).** (Japanese with Latin diagnoses). Shigeo AKIYAMA. (J. Jap. B. **16**, 1940, 98-101, 216-218, 1 text-fig.).

The author has got three Australian species of *Carex*, viz. *C. breviculmis* R. BROWN, *C. Gaudichaudiana* KUNTH and *C. littorea* LABILL. The first and the second species are very similar to the Japanese species *C. leucochlora* BUNGE and *C. Thunbergii* STEUDEL respectively. The third species is held recently by many author to be identical to *C. pumila* THUNB., perhaps with right. The two following new species are noticed besides: *C. pseudo-Thunbergii* and *C. hotaizanensis*.

**150. Studies on a fungus parasitic on muscardine.** (Japanese with English résumé). Kiyosi AOKI. (B.I.S.E.S.T. **9**, 1939, 453-467, 1 pl. and 1 text-figs.-group).

The author has obtained specimens of *Margarotia pyloalis* WALKER (a noxious insect that infests the mulberry-tree) and silkworms which are affected by *Isaria farinosa* (DICKS.) (yellow muscardine). An ascomycetous fungus was found on the latter. The full-grown muscardine was inoculated by the ascospores of the fungus just indicated, or the spores of both fungi were sown together in a nutrient medium, and then the perithecia were developed in the colonies of muscardine. The ascomycetous fungus above indicated was unable to attack living *Margaroma*, so that when the spores of both fungi were sown in the body of this insect, the latter died soon, due to the action of *Isaria*, and then first the perithecia of another fungus came into existence.

This ascomycetous fungus seems to belong to *Ceratostoma*, though its specific name remains yet undetermined. It may be easily distinguished from *C. biparasiticum*, which also lives parasitic on yellow muscardine and is very similar to *Melanospora parasitica* TUL.

**151. Mikrochemischer Nachweis der Flechtenstoffe. XI. Mitteilung. (M. jap. Zfg.).** Yasuhiko ASAHINA. (J. Jap. B. 16, 1940, 185-193, 11 Textfig.).

Die Perlatorinsäure ( $C_{23}H_{38}O_7$ ), welche bisher nur in *Parmelia cetrarioides* DEL. var. *typica* DR. enthalten zu sein bekannt war, wurde neuerdings vom Verf. in europäischer *Cladonia impeza* HARM. neben l-Unsinsäure nachgewiesen (Zusammenarbeit mit NOGAMI). Nach der Ansicht Verfs. soll die farblose Substanz, welche früher ZOPF neben Unsinsäure aus *Cl. impeza* f. *erinacea* extrahiert und "Erinacein" genannt hatte, zu Perlatorinsäure identisch sein.

Inbezug auf die Flechten, welche in kalten oder alpinen Regionen Japans wachsen und sämtlich unter dem einheitlichen Namen *Cladonia alpestris* zusammengefasst sind, gibt es nach der Ansicht Verfs. zwei verschiedene Typen, welche nicht nur in Gestalt und Farbe, sondern auch chemisch unterscheidbar sind. Der erste von denselben ist von der Reaktion PD+ gelb und enthält die Psaromsäure, während der zweite von der Reaktion PD- ist und die Perlatorinsäure enthält. Der erste ist der nordamerikanischen *Cl. alpestris* R. f. *aberrans* zu identifizieren, während der zweite der nordamerikanischen *Cl. Evansi* ABB. ähnlich ist und als eine neue Art den Namen *Cl. pseudoevansi* gegeben wurde.

**152. Critical notes on some Formosan Euphorbiaceae. (I).** Leon CROIZAT and Hiroshi HARA. (J. Jap. B. 16, 1940, 315-326).

The following Euphorbiaceae from Formosa are enumerated with critical notes: *Antidesma pentandrum* (BLANCO) MERRILL, *Bridelia Balansae* TUTCHER, *Glochidion Hayatae* CROIZAT et HARA, nom. nov., *G. dasyphyllum* K. KOCH, *G. puberum* (L.) HUTCHINSON, *G. philippicum* (CAVANILLES), C. B. ROBINSON, *G. assamica* (MÜLL.-ARG.) HOOKER, *G. magnicapsicum* CROIZAT et HARA, var. nov., *G. Fortuni* HANCE, *G. hongkongense* MÜLL.-ARG., *G. lanceolatum* HAYATA.

Lastly, an analytical key for the determination of the *Glochidion* species above cited, is given.

**153. Bacteria and algae in the hot springs of Aso. (Japanese with English résumé).** Yosikazu EMOTO and Yûiti YONEDA. (E.R. 6, 1940, 1-16, 16 text-figs.).

The Aso National Park with its famous volcano Mt. Aso as its center abounds in a number of sulphur and salt hot springs. The authors have studied the bacterial and algal flora there and collected 7 species of bacteria, 18 species and 2 varieties of Cyanophyceae, and 4 species of Chlorophyceae. Among them *Oscillatoria Javis* COPELAND var. *acuta* var. nov. is distinguished from the type by having pointed apices.

In the hot spring Tarumai, *Oscillatoria amoena*, *O. formosa* and *O. splendida* are dominant under 39-47°C and pH=5.6-5.8. In Totinoki hot spring *Lyngbya putealis* and *maiscula* are dominant.

**154. Studies on sclerotial diseases of the rice plant in China. I. Morphology and pathogenicity of *Sclerotium oryzae-sativae* SAWADA. (Japanese with English résumé).** Sigeru ENDÔ. (A.P.P.S.J. 10, 1940, 7-15, 2 text-figs., 11 tables).

A number of local strains of *Sclerotium oryzae-sativae* from various parts of Southern China were examined. The size of sclerotia as well as that of their constituent

cells (length and width) are somewhat different in different strains. Also the pathogenicity of the fungus towards the leaf-sheath of rice plant is different in different strains.

**155. Genetic studies of the flower colours in the Japanese morning glory. X. Complementary genes R and A for the production of flower colours, with special reference to the polymeric constitution of A.** (Japanese with English résumé). Tokio HAGIWARA. (J.J.G. 16, 1940, 49-58).

The following are some of the results of the author's studies on flower colours in the Japanese morning glory. Four complementary factors are necessary for the production of anthocyanin in flowers, viz.  $C_{11}$ , C, R and A.  $C_{11}$  and C are concerned in the production of flavones, while R is concerned in the formation of anthocyanin from flavones, with the cooperation of A. For the colour production in the stem C is not necessary. The gene A, which is considered as the activator of the gene R, seems, as the present studies have shown, to be composed of five genes  $A_1, A_2, A_3, A_4$ , and  $A_5$ , some of which are duplicate factors, etc., etc.

**156. Twin seedlings in the Japanese morning glory.** Tokio HAGIWARA and Michio NONOMURA. (J.J.G. 16, 1940, 118-120, 3 text-figs.).

49 seeds of the strain Bungetu of the Japanese morning glory were sown, and 47 normal seedlings were obtained. From each of the two remaining seeds two radicles were produced in germination—twin seedlings.

**157. Anomalous secondary growth in the axis of *Lophopyxis pentaptera* (K. SCHUM.) ENGLER.** (With Japanese résumé). Tsugio HANDA. (B.M.T. 54, 1940, 41-47+1, 1 text-fig.).

The axis of *Lophopyxis pentaptera* belonging to the Icacinaceae is characterized by its peculiar abnormal secondary growth. At first the cambium ring behaves quite normally, but at a certain time of its development it begins to behave differently on the side of the axis alternating with each of five leaf-orthostichies (phyllotaxis 2/5), inasmuch as here the cambium ring produces a reduced amount of xylem and a correspondingly increased amount of phloem. Since otherwise both xylem and phloem are formed in normal way, a furrow is formed opposite each of the five reduced xylems, and this furrow is filled up by the corresponding phloem-mass, which on account of its shape is known as the phloem-wedge. The continuity of the cambium ring is broken at the places of furrows: the cambium lies outside five projecting normal xylems and at the bottom of each furrow, but entirely wanting at the side of the latter. Thus arises the so-called "interrupted xylem."

So far the mode of abnormal secondary growth agrees with that seen in the Bignoniaceae. Now quite different behaviour will be observed as described below. Further growth of phloem-wedges stops, because the cambium at its bottom becomes inactive, and a new strip of cambium arises outside each phloem-wedge, and is connected with each cambium strip lying outside each of five projecting ridges to form again a continuous cambium ring. Now as the latter forms phloem and xylem in a normal way, the phloem-wedge becomes enclosed within the xylem; the whole xylem seems apparently as it were pierced by the phloem-wedge, whence the name "pierced xylem" given to it.

Later the cambium becomes inactive, the successive development of the cambium ring which arises outside it follows, and a number of secondary rings of xylem and phloem will result.

**158. Ueber Wirkstoffe, die von einem auf *Prunus* Hexenbesen erzeugenden *Taphrina cerasi* sezerniert werden.** (Japanisch m. deutsch. Zfg.). Shizuo HATTORI und Saburo KINOSHITA. (B.M.T. 54, 1940, 58-63, 2 Textfig.).

Die Kultur auf Kartoffel-Glukose-Agar-Nährboden aus einem Hexenbesen von gemeinem japanischem Kirschbaum *Prunus yedoensis* wurde als Material benutzt. Durch die Aetherextraktionsmethode wurde eine sehr kleine Menge einer rötlichbraunen öligen Substanz erhalten. Die kaltgesättigte wässrige Lösung der letzteren wurde 4- und 10-fach verdünnt und für die Versuche verwendet. Die *Avenakeimlinge* wurden auf das mit solchen Lösungen getränkte Filtrierpapier gelegt. Es wurde dabei beobachtet, dass diese Lösungen das Streckungswachstum ihrer Wurzeln beträchtlich hemmen, obschon die Koleoptile gar keine Hemmung ihrer Streckung erfährt. Die Kontrollversuche mit Heteroauxin haben gezeigt, dass ihre Lösung von der Konzentration 10 mg/L und 625 $\gamma$ /L die Streckung von beiden Wurzeln und Koleoptilen hemmt. Es wurde weiter festgestellt, dass die obengenannte Lösung der *Taphrina*-Substanz stärker wirkt als Heteroauxinlösung von der Konzentration 10 mg/L, und obschon solche Heteroauxinlösung das Streckungswachstum der Koleoptilen hemmt, ist dies keineswegs der Fall bei Benutzung der *Taphrina*-Substanz, darum ist es wahrscheinlich, dass die Wirkstoffe der *Taphrina*-Substanz und das Heteroauxin ganz verschieden sind.

Die weiteren Experimente der *Taphrina*-Substanz haben die obige Annahme weiter bestätigt.

Zum Ende bemerken die Verff., dass ob die obengenannte *Taphrina*-Substanz die Ursache der Hexenbesen sei, noch nicht entschieden ist.

**159. A revision of the Japanese *Trachelospermum*.** (Japanese and English). Sumihiko HATUSIMA. (J. Jap. B. 16, 1940, 20-30, 4 text-fig.).

At first the general morphology of the genus *Trachelospermum* is described. A key (in English) for the species identification is given. In all 5 species are enumerated, among which the following is new and provided with a diagnosis, viz. *Trachelospermum liukiense* HATUSIMA sp. nov.

**160. On the anthocyanin in the flowers of Japanese *Iris*.** (Preliminary note). (Japanese with English résumé). Kôzô HAYASHI. (B.M.T. 54, 1940, 23-29).

The author's own summary runs as follows:

The pigments occurring in the violet-red and the blue flowering variety of Japanese *Iris* (*Iris ensata* THUNBERG var. *hortensis* MAKINO et NEMOTO) have been isolated and studied. After purification the pigments from the petals of these two garden varieties were found to be identical to each other. The colouring matter is an anthocyanin, which yields, on hydrolysis with boiling 20% HCl, glucose and a sugar-free pigment. The latter was identified as malvidin chloride,  $C_{27}H_{35}O_7Cl$ .

**161. Studies on septorioses of plants VI. *Septoria Glycines* HEMMI causing the brown spot disease of soy-bean.** Takewo HEMMI. (M.C.A., K.I.U. No. 47, 1940, 1-14, 1 pl. and 3 tables).

The brown spot disease of soy-bean caused by *Septoria Glycines* HEMMI appears in each summer on both sides of leaves commonly as brown or light reddish brown spots, of which finally the color turns blackish brown. In artificial culture on potato decoction agar with sucrose the pycnidia and pycnosporos were obtained by the author. In respect to the temperature relation it was found that the pycnosporos germinate between 16-36°C, the germ-tube being largest at 28°C. The fungal growth takes place



between 5–36°C, optimum 24–28°C. The inoculation of pycnospores on leaves was successful, the incubation period being  $\pm 10$ –14 days.

Further, it was proven experimentally that the fungus is able to cause the disease by means of seed-borne as well as soil infection (over-wintering and dissemination).

**162. Materials for a rust-flora of Riukiu Islands I.** (With Japanese résumé). Naohide HIRATSUKA. (B.M.T. **54**, 1940, 157–167, 198–199).

The following 55 species belonging to 15 genera are enumerated, viz. *Milesina* (2 species), *Pucciniastrum* (1), *Phakospora* (4), *Coleopucciniella* (1), *Coleosporium* (5), *Kuehneola* (1), *Hamasporea* (1), *Policstelium* (1), *Angiopsora* (1), *Pilcolaria* (1), *Ravenalia* (2), *Phragmidium* (1), *Uromyces* (1), *Puccinia* (10), *Aecidium* (5).

**163. Additional notes on Uredinales of Shikoku.** (With Japanese résumé). Naohide HIRATSUKA. (J. Jap. B. **16**, 1940, 327–329).

This paper contains the supplementary note to "Uredinales of Shikoku" published some years ago by the author and YOSHINAGA (cf. this JOURNAL **8**, (44), No. 176). 7 species from the genera *Milesina*, *Phakospora*, *Chrysomyxa*, *Xenodochus*, *Phragmidium*, *Puccinia*, *Aecidium* and a number of new host plants are given.

**164. Nuntia ad floram japonicae XLI–XLII.** (With Japanese résumé). Masazi HONDA. (B.M.T. **54**, 1940, 1–4, 32–34, 223–224, 247).

The following plants are new: *Cardamine impatiens*, L. var. *tenuissima* var. nov., *Agropyron ciliare* FR. var. *eriorhabdum* var. nov., *Rhododendron macrosepalum* MAX., var. *diplandrum* var. nov., *Epilobium cephalostigma* HAUSSKNECHT f. *leucanthum* f. nov., *Prunus Sargentii* REHDER var. *pendula* HONDA var. nov., *Fraxinus Sieboldiana* BLUME var. *Koiei* HONDA var. nov., *Amethystanthus effusus* (MAX.) HONDA comb. nov. f. *leucanthus* f. nov., *Lychnis Miqueliana* ROHRB. f. *albescens* f. nov., *Clinopodium Fauriei* HARA f. *albiflora* HONDA f. nov., *Orthodon punctulatum* OHWI f. *leucanthum* HONDA f. nov., *Amethystanthus japonicus* NAKAI f. *albidus* (NAKAI) HONDA comb. nov. var. *albiflorus* HONDA var. nov., *Arisaema Sugimotoi* NAKAI f. *variegata* HONDA f. nov., *Trichosanthes cucumeroides* MAX. var. *stenocarpa* var. nov., *Rhus trichocarpa* MIQ. var. *humilis* var. nov., *Oxycoccus microcarpus* TURCZ., var. *kirigaminensis* HONDA et TOBITA var. nov., *Clinopodium Omuranum* HONDA sp. nov.

**165. Vorkommen des *Tetradontium Brownianum* (DICKSON) SCHWAEGRICHEN in Japan als neuem Fundgebiet.** Yoshiwo HORIKAWA und Sadazi IWAMASA. (P.I.A. **16**, 1940, 17–20, 3 Textfig.).

Das Vorkommen des winzigen Lebermooses *Tetradontium Brownianum* und seiner Varietät *rigida* (HEDWIG) JURATZKA war bisher bloss im europäischen Kontinent und England bekannt, während die Varietät *repandum* (FUNK) nicht nur in Europa, sondern auch in Kaukasus und Nordamerika aufgefunden worden ist, sodass HERZOG diese Art als europäisch-atlantisches Element bezeichnet hatte. Neuerdings haben aber die Autoren dieses Aufsatzes das Vorkommen der Varietät *repandum* in Japan festgestellt, und zwar sowohl in Hokkaidō als in Honsyū, d. h. weit östlich von dem Zentralgebiete der Verbreitung dieser Art.

In dem vorliegenden Aufsatz ist das in Rede stehende Lebermoos eingehend beschrieben mit vielen lehrreichen Abbildungen.

**166. Contributions to the bryological flora of Eastern Asia (VII).** (With Japanese résumé). Yoshiwo HORIKAWA. (J. Jap. B. **16**, 1940, 163–171, 3 text-figs.).



Among a number of Japanese Bryophytes enumerated in this paper, the three following species are noted as remarkable: *Anthelia Juratskana* (LIMP.) TREV., *Tremetodon longicollis* MICHX., and *Aulacomnium androgynum* (L.) SCHWAEGER. The first two were collected in Saghalien, and the third in Saghalien as well as in Hokkaidô.

**167. Species generis *Euphorbiae Imperii Japonici* (I). I. HURUSAWA. (J. Jap. B. 16, 1940, 330-346, 1 figs.-group).**

After a general consideration the following species are enumerated: *Euphorbia Tirolea* LINN., *E. Lathyris* LINN., *E. Helioscopia* LINN., *E. Peplus* LINN., *E. Fischeriana* STEUDEL.

**168. Tetraploid Asiatic cotton plants induced by the colchicine treatment.** (Japanese with English résumé). Sadamasa HUTUKAITI. (B.Z. 8, 1940, 597-601, 5 text-figs.).

In a number of strains of Asiatic cotton (*Gossypium arboreum*,  $n=13$ ), some tetraploid plants were got, either by the application of 0.5% watery solution of colchicine to the growing tip or by immersing seeds in its 0.3% solution. The tetraploids are lower than the diploids, but much more branched. Stomata, epidermal cells and pollen grains are considerably larger in tetra- than in diploids. Seeds of tetraploids are much heavier than those of diploids (0.060-0.106 gr), which is nearly equal to those of Upland cotton (*G. hirsuta*). Fibres of tetraploids are longer, wider, and greater in tensile strength than those of diploids, while in respect to the number of convolutions per unit length just the reverse is the case.

**169. Characteristics and control of *Venturia* disease of Japanese pears.** (Japanese). Suehiko IKATA. (A.H. 15, 1940, 133-144, 8 text-figs.).

According to the results of the author's investigation, the propagation of *Venturia pirina* (COOKE) ADERHOLD takes place exclusively through the conidia and ascospores. The data of some authors on the propagation through other modes seem to be due to the confusion of other species with the present one.

The author has made some experiments concerning the overwintering of conidia and ascospores on leaves and branches. On the basis of such experiments and of the fact that the ripening of ascospores takes place some time after the flowering the author thinks that the infection of this disease in early spring takes place, not through the ascospores, but chiefly through the conidia which have overwintered on leaves and twigs, while the infection in middle or late spring takes place through ascospores.

Experiments of artificial inoculation have shown that the duration of incubation lies between 21-32 days. Artificial inoculation of European pears has always given negative results.

As to the relation between *Venturia* and the temperature it was observed that for the mycelial growth optimum  $\pm 20^\circ$ , maximum  $25-39^\circ$ , minimum  $10^\circ$ . For the germination of conidia optimum  $22-23^\circ$ , at  $28^\circ$  no growth but even at  $8^\circ$  it may take place.

Methods of control are described at the last part of the paper.

**170. Studies on the disease of *Juncus effusus* var. *decipiens* BUCH. I. Leaf-rot disease.** (Japanese). Suehiko IKATA and Masazi YOSIDA. (S.B.A.E.S., O.P. No. 35, 1940, 47 pp. and 10 pls.).

In respect to *Juncus effusus* L. var. *decipiens* BUCH., which is the material for the mat manufacture several diseases, either physiological or parasitic, have hitherto been recognized. In the present paper the authors describe a leaf-rot disease which recently

has spread in some regions of the Prefectures Okayama, Hiroshima and Kagoshima. The symptom of this disease consists in forming flecks in stem and leaf-sheath, and leading finally to the death of the whole stock. The causal fungus is *Leptosphaeria juncina* (AUERSW.) SACC. known already in Europe since some time ago. Its imperfect generation is called *Stagnospora innumerosa*. The perfect generation is found within the living tissue in summer and autumn, while its imperfect generation is seen in spring and autumn. The name *Stagnospora* is properly to be cancelled away. The artificial culture by the authors has given rise to pycnidia, but never to ascus-fruits. For the fungal growth 25°C and pH=±5-6 are optima. When the inoculation is done, the pycnosporos produce the germ-tubes; at the upper end of each of the latter an appressorium is formed, from which the infective tubes issue out and bohr through the cuticle of the host to penetrate into the interior of epidermal cells.

In respect to infection the ascospores seem to play no important role. The infection takes place chiefly through the pycnosporos as well as the chlamydospores produced on aerial hyphae.

**171. Second note on the Tuberales of Japan.** Sanshi IMAI. (P.I.A. 16, 1940, 153-154, 3 text-figs.).

The fungus referred to in this paper was found to form an ecto-endotrophic mycorrhiza on the root of *Populus nigra* L. and rarely on that of *Acer palmatum* THUNB.

This fungus belonging to the Tuberales is related to some species of *Tuber*, *Mattiolomyces* and *Delastria*. The lack of venae externae distinguishes it from *Tuber*, the small number of the spores in each ascus (4 in maximum) and their ellipsoidal shape exclude it from *Mattiolomyces*, and further the ellipsoidal spores and the poor development of the venae internae indicate that it does not belong to *Delastria*. The author has created for it a new genus *Mukagomyces* containing one single species *M. Hiromichii* sp. nov.

**172. Observations on the Japanese fungi (V).** (Japanese and English). Rokuya IMAZEKI. (J. Jap. B. 16, 1940, 264-272, 6 text-figs.).

The following fungi are enumerated with illustrations: *Polyporus* (*Tynomyces*) *sulphureus* BULLIARD, *P. (Tynomyces) sambucinus* LLOYD, *P. calvatioides* IMAZEKI, nom. nov.

**173. On the influence of sunlight on the incubation period and the development of the blast disease and the Helminthosporium disease of the rice plant.** (Japanese with English résumé). Junzo IMURA. (A.P.P.S.J. 10, 1940, 17-26).

The writer's experiments refer to the blast and the *Helminthosporium* disease of the rice plant. The results are quite identical in both cases. The results are as follows.

The mean incubation period as well as the pathogenicity increased in the plants shaded with a single sheet of black cotton before the inoculation, which will indicate the favourable effect of shading towards the causal fungus. On the contrary, the shading after inoculation until the development of the disease shortens the mean incubation period, and besides, the pathogenicity seems to become less intense, which will point out that excessive shading is not favourable for the fungus development.

**174. Studies on Japanese aquatic fungi II. The Blastocladiaceae.** Hiroharu INDOH. (Sc. Rpts., T.B.R.D. 4, 1940, 237-284, 34 text-figs.).

The family Blastocladiaceae contains three genera, viz. *Blastocladia*, *Blastocladia* and *Allomyces*.

The introduction of the paper treats of the structure of the zoosporangia, the significance of the so-called chlamydocists (resting spores), as well as the sexual reproduction.

As to the Japanese species of *Blastocladia* and *Allomyces*, the following are described, and the key for the identification are given.

*Blastocladia*: *B. Pringsheimii* REINSCH with its four types of basal bodies, *B. globosa* KANOUSE, *B. ramosa* THAXTER, *B. incrassata* INDOH sp. nov., *B. prolifera* von MINDEN, *B. sp. indet.* Besides, 8 exotic species not yet found in Japan are described.

*Allomyces*: *A. arbuscula* BUTLER, *A. javanicus* KNIEP var. *japonensis* INDOH var. nov., *A. moniliformis* COKER et BRAXTON, *A. neo-moniliformis* INDOH sp. nov.

A few species of imperfect forms are noticed.

At the end of the paper the geographical distribution of the species of *Blastocladia* is indicated in a table.

**175. *Studia lichenum japoniae* II.** Sunao INUMARU. (A.P.T.G. 9, 1940, 51-59, 5 text-figs.).

*Nephroma squamigeum*, var. *plumbeum*, *N. parile* var. *fusco-nigricans* are new species and varieties, and described.

A key for the determination of the Japanese species of the genus *Nephroma* is given.

**176. Studies on partially sterile rice plants. I.** (Japanese). Junichi ISHIKAWA. (P.G.S.S.J. 12, 1940, 25-30, 7 tables).

A partially sterile Japanese strain of rice studied by the author produces a very few partially sterile offspring besides a large number of fertile ones (fertile: sterile 7:1). In the next generation these fertile offspring give rise exclusively to fertile individuals, while the partially sterile offspring will produce a very few partially sterile and a great number of fertile offspring, just as in the preceding generation.

The real weight of grains is larger and the specific gravity smaller in the partially sterile individuals than in fertile ones. The rate of germination is smaller in the former than in the latter (98% versus 94%). Treated with dilute KCl solution (0.1-1.0%) the grains of partially sterile strain do not much decrease in their germination rate, but treated with conc. KCl solution (2-5%) their grains are more considerably reduced in their germination rate than those of fertile strain. The treatment of seeds by ultra-violet or X-rays seems to increase the germination rate in both partially sterile and fertile strains.

**177. Fungi of the Bonin Islands IV-V.** Seiya ITO and Sanshi IMAI. (T.S.N.H.S. 16, 45-51, 120-138).

The authors have enumerated 30+56 species of fungi collected in the Bonin Islands, of which the following are new: *Pluteus horridilamellus*, *P. Okabei*, *P. Machidae*, *P. Daidoi*, *P. cernuculosus*, *Leptonia brunneola*, *Pholiota tabacinirugosa*, *P. Livistonae*, *Gymnopilus noviholcivrhus*, *Crepidotus subpurpureus*, *Agaricus Hahashimensis*, *A. silvicola*, SACC. f. *immutatus*, *Hypholoma boninense*, *H. stellatofurfuraceum*, *Coprinus boninensis*, *Lactarius Ogasawarashimensis*, *Russula boninensis*, *Polyporus Hinoi*, *P. Schimae*, *Polystictus gramocephalus* (comb. nov.), *Hexagona papyraceo-resupinata*, *Fomes Terminaliae*, *Boninohydnum* gen. nov. containing *B. Pini*, *Stereofomes palmicola*, *Stereum obliquulum*, *Hymenochaete palmicola*, *H. pertenuis*, *Cyphella cyatheae*, *Lloydella Okabei*, *Tremella boninensis*, *Heterochaete Ogasawarashimensis*, *Hypoxyylon fusco-*

*nigrum*, *H. macroannulatum*, *Chromocrepis microasca*. The diagnoses are given for each.

**178. On the species of *Neckera* in Japan.** Sadazi IWAMASA. (J.S., H.U. 4, 1940, 19-36, 2 pls. and 8 text-figs.).

The investigations hitherto done on the Japanese species of *Neckera* seem to the author to be quite imperfect. In the present paper he has described a number of Japanese *Neckera* species in detail with illustrations. The species contained in this paper are as follows: *Neckera Fauriei* CARDOT, *N. laeviscula* CARDOT, *N. pusilla* MITTEN, var. *Murattae* (NOGUCHI) HORIKAWA et IWAMASA, comb. nov., *N. flexiramea* CARDOT, *N. Konoï* BROTHERUS, *N. Nakasimae* (IHSIBA) NOGUCHI.

**179. Beobachtungen einiger thiotropher Seen Japans mit besonderer Berücksichtigung der Schwefelbakterien. II.** Tadao JIMBO. (Sc. Rpts., T.I.U. 15, 1940, 7-11, 1 Textabb.).

Die Beobachtungen des Verfs. betreffen einen "Wakuike" genannten thiotrophen See, welcher in halber Höhe des Berges Iwakura nahe der Stadt Nagano (Sinano) sich befindet. Der Verf. hat gefunden, dass im Winter kein Schwefelwasserstoff im Wasser desselben enthalten ist, aber im Sommer er in unterer Schicht (3,5 m. und tiefer) vorhanden ist. An der oberen Grenze der letzteren hat der Verf. *Chromatium Weissei*, eine schwefelhaltige Purpurbakterie sowie *Chloronium mirabile*, eine bewegliche grüne Bakterie nachgewiesen. Als diese letztere niemals ausserhalb der schwefelwasserstoffhaltigen Schicht beobachtet wird, ist es ganz klar, dass sie diesen Stoff sowie das Licht bedürfen wird. Wenn man den im Winter gesammelten Tiefenschlamm des Sees zusammen mit etwas Bodenwasser für einiger Zeit aufbewahrt und zwar in einem beleuchteten warmen Kammer, wird man bald die Entwicklung von *Chromatium Weissei* und *Chlorobium limicola* wahrnehmen, was uns zeigt, dass alle diese Organismen im Schlamm überwintern.

**180. The effect of abnormal environment on the pollen formation in certain species- and genus-hybrids.** (Japanese). Fuyuwu KAGAWA. (P.C.S.J. 12, 1940, 1-15, 10 tables).

If in  $F_1$ -generation of certain species- and genus-hybrids the diad pollen grains are developed, owing to certain environmental factors, the formation of the amphidiploid plants would not be quite impossible. The present paper presents some attempts of the author towards this purpose, of which the one has given negative and the other positive results.

In  $F_1$  of *Triticum compactum* ( $n=21$ )  $\times$  *Secale cereale* ( $n=7$ ) the author has tried experimentally to produce diad pollen cells by means of extreme dryness, but there was no appreciable difference of the number of diad cells in dried and control (watered) materials.

The  $F_1$  hybrids of *Quamoclit angulata* ( $2n=28$ )  $\times$  *Q. pennata* ( $2n=30$ ) were exposed to high temperature ( $44-50^\circ$ ) for 15-35 minutes. In this case the number of diad pollen grains was much greater in heated than in control materials, thus, for instance, 29.6 and 30.1% against 15.4 and 12.8% respectively.

**181. Earliness as influenced by seasonal growth habit in wheat hybrids.** (Japanese with English résumé). Yôiti KAKIZAKI and Sinzaburo SUZUKI. (J.J.G. 16, 1940, 59-68).

The following is the authors' own summary of the paper.

The authors reported that (1) the intensity of nature of winter growth habit in



wheat varies with varieties, a variety without this nature being an absolute spring variety; (2) this "winter nature" is cancelled completely or partially either by a low temperature during germination and early growth or by a short-day condition under which young plants grow; and that (3) in a case where a cancellation of winter nature is insufficient on account of high temperature or long days, earing is retarded and becomes late or ceased owing to residual winter nature. The authors reported also that, in a greenhouse culture (ca. 22°C)  $F_1$  hybrids of all the crosses SE (varieties with lower winter or higher spring nature, earlier earing)  $\times$  WL (varieties with higher winter nature, later earing) were later in earing than the respective SE parents but earlier than WL, while those of all the crosses SL  $\times$  WE were earlier than either of the respective parents. This phenomenon was interpreted as follows: The low winter nature is dominant or nearly so over the high, and in the earliness apart from the retarding influence of winter nature the  $F_1$  behaves its earing between both parents. Then,  $F_1$  of SE  $\times$  WL can not be earlier than SE but is of course earlier than WL. In SL  $\times$  WE, earing of WE is retarded by residual winter nature owing to the high temperature condition and is not early in this case in spite of its early genetic factors; whereas  $F_1$  has spring or low winter nature as SL parent and its earing is influenced by the early genetic factors coming from WE parent, and becomes earlier than either SL or WE.

Spring sowings carried out at various dates with a WL  $\times$  SE cross and 4 WE  $\times$  SL crosses showed similar results as in the greenhouse culture mentioned above. In each WE  $\times$  SL cross, the number of days earlier in  $F_1$  as compared with WE parent was increased with lateness of sowing. This is due to the retardation in WE parent by the increased residual winter nature and to the fastening in  $F_1$ , owing to higher temperatures and longer days towards the later season. When germinated seeds were chilled at 1°C for 80 to 100 days before sowing and winter nature was thus cancelled,  $F_1$  became intermediate between both parents in earing expected in all sowings even in WE  $\times$  SL.

In genetic experiments on earliness of wheat, the result may be, provided more or less degrees of winter nature is concerned, quite unlike according to the different degrees of cancelling action of winter nature, due to the difference of locality, sowing time, yearly climate.

**182. A new *Pandanus* from Sumatra.** (Japanese with Latin diagnosis). Ryôzô KANEHIRA. (J. Jap. B. 16, 1940, 101-105, 2 text-figs.).

*Pandanus pungens* KANEHIRA, a new species from Sumatra is described with illustrations. Besides, 13 species of *Pandanus* from Sumatra are enumerated.

**183. Karyological studies in *Crocus* II.** K. KARASAWA. (Jap. J. B. 11, 1940, 129-140, 73 text-figs.).

**184. On the flora and fauna of the River Tamagawa, Akita Prefecture.** (Japanese with English résumé). Yoshiiti KASAI. (E.R. 6, 1940, 49-53, 55 text-figs.).

The River Tamagawa in the Akita Prefecture is characterized by the intense acidity of its stream. The author's data on the flora of this river are briefly as follows:

Among almost 30 species of plants living in this stream all are diatoms, except *Aplozia crenulata* (Hepaticae) and *Microspora tumidula* (Chlorophyceae). *Pinnularia* may live in water of pH 1.9, but is found in many other places of lower acidity throughout the whole stream; it is indeed an easily adaptable organism. *Eunotia* lives only in places of intense acidity (pH 3.0-4.5). *Aplozia* and *Microspora* are found exclusively



in places between pH 3.4–4.2. In the mountain torrent there are only few species but in lower land stream, where pH gradually approaches the neutral state, the species number increases, while the individual number of each species is greatest in the middle region of the stream.

**185. Genetische Studien an gestreiften Sippen von *Celosia cristata*.** (Japanisch m. deutsch. Zfg.). Hitoshi KIHARA. (B.Z. 8, 1940, 975–990, 1 Farbentaf.).

Bei *Celosia cristata* ist ein neues mutables Gen für die "pink" Farbe aus einem gestreiften Individuum entstanden, und zwar als der Folge der Kreuzung gelbkonstant  $\times$  gelbmutabel. Dieses Gen, welches  $a_p$  genannt wird, ist durch seine Mutabilität zu A-Gen (Magenta) ausgezeichnet, wobei die betreffende Mutation nicht auf einmal, sondern durch die kleinen Sprünge in der Farbenintensität auftritt. Dabei unterscheidet der Verf. sechs Farbengrade,  $p_0, p_1, p_2, p_3, p_4$  und  $p_5$  in aufsteigender Reihenfolge, d.h. der erste die niedrigste (hellste) und der letzte die höchste (dunkelste) Stufe darstellt. Dieser Farbengradunterschied wird besonders deutlich an den Blütenständen hervortreten.

Das soeben erwähnte Mutieren des Gens  $a_p$  nach verschiedenen Farbengraden lässt oft an einem Individuum oder seinem Teile phänotypisch das aus zwei verschiedenen Graden bestehende Mosaik entstehen, und in solchen Fällen gehören sie meistens zu den benachbarten Stufen, z.B.  $p_0$  und  $p_1$ ,  $p_1$  und  $p_2$  usw., wenn auch das Zusammenkommen von zwei von einander mehr entfernten keineswegs ausgeschlossen ist, wie z.B. Magenta-Streifung an dem  $p_0$ -Teile usw.

Der Verf. hat während vielen Jahren eine Reihe von Selbstungs- und Kreuzungsversuchen an verschiedenen pinkischen Individuen ausgeführt, von denen es hier von der Beschreibung der Einzelheiten abgesehen werden muss. Unten werden wir bloss auf einige festgestellte wichtige Tatsache hinweisen.

Die Selbstungsversuche haben vor allem festgestellt, dass je höher (dunkler) der Farbengrad der untersuchten Individuen und ihrer Teile ist, desto höher (dunkler) derselben der Nachkommen sein wird. Das gleiche gilt auch für die Farbe der Kreuzungsfolge, z.B. pink  $\times$  gelbkonstant.

Die Individuen der niederen Farbenstufe,  $p_0, p_1, p_2$  sind keineswegs konstant, indem jedes derselben durch seine starke Tendenz nach der höheren Stufe zu mutieren ausgezeichnet ist. Diejenigen der höheren (dunkleren) Stufe  $p_4$  und  $p_5$  sind im allgemeinen stabil und können konstant bleiben, obgleich der Endzustand ihres Mutierens A (Magenta) ist, so um einen Beispiel hervorzuheben beobachtet der Verf. eine  $p_4$ -Pflanze, wobei während vier Generationen (Selbstung) weder Spaltung noch Streifung zu erkennen war.

Es wurde weiter festgestellt, dass die Mutabilität des Gens  $a_p$  keineswegs durch das Vorhandensein irgend eines anderen Genes beeinflusst wird, ausgenommen unter der Einwirkung des A-Genes, wobei die sonst ganz stabilen Individuen zur A-Mutation geführt werden können.

Kurz: das  $a_p$ -Gen besitzt eine starke Tendenz zum Uebergang zu einem stabilen Zustand und diese wird durch die kleinen Sprünge ermöglicht. Der Endzustand der Mutation ist A (Magenta), wenn auch das Gen beim  $p_4$  oder  $p_5$  stabilisiert werden kann.

**186. Formation of haploids by means of delayed pollination in *Triticum monococcum*.** (Japanese with English résumé). Hitoshi KIHARA. (B.M.T. 54, 1940, 178–185, 1 text-fig.).

The formation of haploids has already been observed in *Triticum monococcum* by the use of X-rayed pollen or even under natural condition. The author was able to

see the production of haploids much more abundantly than hitherto recognized by means of delayed pollination (37.50% against 0.54 under natural condition and 13.66% in case of using X-rayed pollen).

*Triticum monococcum* L. var. *vulgare* KÖRN. was emasculated nearly 3 days before flowering and after 2-9 days the pollination was done. The pollination after 9 days has given rise to the greatest number of haploids.

In respect to the cause of this phenomenon the author has based his conclusion upon the observation of KATAYAMA. The latter could observe in the ovaries of emasculated and not pollinated flowers the formation of multicellular embryo with no endosperm, though no further development of such ovaries has taken place. The author thinks that in emasculated flowers above mentioned the haploid embryo is produced from the egg-cell parthenogenetically and the endosperm through the usual triple fusion.

Twin seedlings are often observed in case of cross-pollination, their percentage being high, so, for instance, 3 pairs of twins among 195 seedlings.

**187. Weitere Untersuchungen über die pentaploiden *Triticum-Bastarde* XII. Schlussmitteilung.** Hitoshi KIHARA und Seiji MATSUMURA. (Jap. J. B. 11, 1940, 27-39, 3 Textabb. u. 5 Tab.).

**188. *Hypericum* of Formosa.** (With Japanese résumé). Yojiro KIMURA. (B.M.T. 54, 1940, 79-88, 111-113, 66 text-figs.).

A key to the sections of Formosan *Hyperica* as well as that for Formosan species of the same are given. The following are enumerated or described: *Hypericum pseudopetiolum* KELLER, *H. erectum* THUNB. var. *angustifolium* Y. KIMURA, *H. Nagasawai* HAYATA var. *nigrum* Y. KIMURA, var. nov., *H. randaiense* HAYATA, *H. taiwanianum* Y. KIMURA sp. nov., *H. nokoense* OHWI, *H. Hayatae* Y. KIMURA sp. nov., *H. Suzukianum* Y. KIMURA sp. nov., *H. Sampsoni* HANCE, *H. Aescylon* L. var. *genuinum* MAX., *H. japonicum* THUNB. var. *typicum* HOCHREUTINER, var. *lanceolatum* Y. KIMURA var. nov., *H. patulum* THUNB., *H. salicifolium* SIEB.

**189. Ueber den Einfluss des elektrischen Stromes auf die Rhythmik der Protoplasmaströmung bei den Myxomycetenplasmodien.** (Japanisch in. deutsch. Zfg.). Saburo KINOSHITA. (B.M.T. 54, 1940, 52-57, 4 Tab.).

Bei der rhythmischen Protoplasmaströmung in den Myxomycetenplasmodien, bedingt die Vergrößerung der sog. Strömungsrate  $\frac{\text{Zeitdauer der progressiven}}{\text{Zeitdauer der retrogressiven}}$

Strömung die Beförderung des Vorwärtskriechens. Weiter ist es früher durch den Verf. gezeigt worden, dass der auf dem Frontteile des Plasmodiums einwirkende Wuchsstoff dessen elektrischen Potentialwert erhöht, die Strömungsrate vergrößert und die positive Chemotaxis des Plasmodiums verursacht (vgl. diesen JOURNAL 10; (70), Nr. 252). Als es nicht unwahrscheinlich sein mag, dass bei von ihm früher nachgewiesenen negativen Galvanotaxis des Myxomycetenplasmodien (vgl. diesen JOURNAL 10, (26), Nr. 105) das gleichartige Verhältnis wie bei den obengenannten Wuchsstoffen bestehe, führte der Verf. den folgenden Versuch aus. Wenn nämlich, mittels der unpolarisierbaren oder Platinelektroden der negative Pol eines Akkumulators an Agarboden in gewisser Entfernung vom Frontteile des kriechenden Plasmodiums von *Didymium nigripes* var. *ranthopus* gelegt wird, wird sein Potentialwert erhöht, was zur Vergrößerung der Strömungsrate und zur Beförderung der Vorwärtskriechens der Plasmodiums nach der Kathode führt. Dagegen durch Applizierung

des elektrischen Stroms in umgekehrter Richtung wird die Strömungsrate verkleinert. Diese Ergebnisse werden somit die oben zitierte Annahme des Verfs. völlig bestätigen.

**190. Ein Apparat zur Messung des bioelektrischen Potentials.** (Japanisch m. deutsch. Zfg.). Saburo KINOSHITA. (B.M.T. 54, 1940, 102-106, 3 Textabb.).

In der vorliegenden Mitteilung beschreibt der Verf. ein Vakuumrohre-Potentiometer, welches von Proff. SHIBATA und SHIBUSAWA zum Zwecke der bioelektrischen Potentialmessungen zusammengestellt ist. Der Apparat misst an biologischen Objekten die Potentialdifferenzen bequem und schnell mit einer Genauigkeit von  $\pm 0.2$  mV.

**191. Ueber den Einfluss der Verwundung auf die Potentialverteilung beim Hypokotyl von *Helianthus annuus*.** (Japanisch m. deutsch. Zfg.). Saburo KINOSHITA. (B.M.T. 54, 1940, 231-236, 3 Textfig. und 1 Tab.).

Im vorliegenden Aufsatz wird der Einfluss der Verwundung des Hypokotyls beim Sämling von *Helianthus annuus* auf die elektrische Potentialverteilung studiert. Nach den Verfs. Experimenten verursacht die Stichwunde mit einer Glasnadel eine deutliche negative Schwankung, deren Grösse je nach verschiedenen Teilen verschieden ist, so z.B. ist sie viel grösser an der Spitzenregion als an der Basis. Wenn beide, die Spitze und die Basis, gleichzeitig verwundet werden, verringert sich die Potentialdifferenz zwischen beiden erheblich. Der obengenannte Einfluss der Verwundung verschwindet gewöhnlich nach 30 Minuten.

**192. Discussion on the genus *Pycnostelma* BUNGE.** (Chiefly in Japanese). Masao KITAGAWA. (J. Jap. B. 16, 1940, 18-20, 1 text-fig.).

The genus *Pycnostelma* BUNGE contains now 4 distinct species, viz. *Pycnostelma paniculatum* K. SCHUMANN, *P. lateriflorum* HEMSLEY, *P. Esquirolii* LÉVEILLÉ and *P. mukudense* KITAGAWA. The author thinks that this genus has no characteristics distinguishing it from the genus *Vincetoxicum*, so that all species of the former should be rightly transferred to the latter.

Some discussions on the genus *Cynanchum* are contained in this paper. According to the author all Japanese and Manchurian plants hitherto recognized as belonging to the genus *Cynanchum* should also be included among the genus *Vincetoxicum* with a few exceptions.

**193. An enumeration of Compositae of Formosa IV.** Siro KITAMURA. (A.P.T.G. 9, 1940, 28-38).

Plants belonging to the following genera are enumerated:

*Glossogyne* (1 sp.), *Tridax* (11), *Bidens* (4, 1 var.), *Synedra* (1), *Chrysanthemum* (4), *Cotula* (1), *Centipeda* (1), *Soliva* (1), *Artemisia* (12, 1 var. nov.), *Gynura* (3, 1 var.), *Petasites* (1), *Erechtites* (2), *Syneilesis* (2), *Cacalia* (2), *Emilia* (3), *Farfugium* (1, 2 var.), *Senecillis* (3), *Senecio* (5, 1 var.).

**194. Shiobara Pleistocene fossil flora.** (Japanese). Gen'iti KOIDZUMI. (A.P.T.G. 9, 1940, 1-27, 2 text-figs.).

The Pleistocene fossil flora of Shiobara district was known to contain 35 families, 58 genera and 115 species (ENDŌ), but the author could add to it 3 families, 9 genera and 14 species. In this flora, which is almost similar to the recent one, the genera *Betula*, *Alnus* and *Acer* are most predominant, though the individual number of *Fagus japonica* is in maximum.

The last part of the paper is occupied by the description of plants of this period

containing 21 families, 32 genera and 50 species. Below the names of these families will be enumerated: Gymnogrammaceae, Pinaceae, Cupressaceae, Betulaceae, Fagaceae, Ulmaceae, Cercidiphyllaceae, Berberidaceae, Ceratophyllaceae, Hamamelidaceae, Rosaceae, Aceraceae, Tiliaceae, Actinidiaceae, Theaceae, Haloragidaceae, Cornaceae, Clethraceae, Ericaceae, Oleaceae, Caprifoliaceae.

**195. Contributiones ad cognitionem florum Asiae Orientalis.** (Continuation). Gen'iti KOIZUMI. (A.P.T.G. 9, 1940, 71-81).

The following new species are described among others:

*Gastrodia foetida*, *Isopyrum pterigionocaudatum*, *C. corensis*, *C. kenpukwan*, *Salix Tagawana*, *Chenopodium formosanum*, *Arundinaria Babatancosiana*, *A. mitinokuensis*, *A. nikkomontana*, *A. tsukubaensis*, *Pleioblastus mollissimus*, *P. naucinopilus*, *P. praeterritus*, *Sasa longifolia*, *S. sandangorgiana*, *S. velutinosa*, *S. Arakiyeitiana*.

**196. On the vitamin C (ascorbic acid) content of herbaceous plants and marine algae, considering factors influencing it.** Tatsuo KOIZUMI and Tomio KAKUKAWA. (Sci. Rpts., T.I.U. 15, 1940, 105-120, 5 tables).

The authors have first of all determined the quantity of vitamin C contained in leaves of more than 50 species of green herbaceous Phanerogams and few marine algae (green, brown and red). It was seen that ascorbic acid is present more abundantly in reduced form than in oxidized, though the relatively high content of oxidized vitamin C is recognizable in light plants than in shade ones. Since it was found that the shade plants contain vitamin C more highly in sunny place than in shade within the limit of their survival, it may be said that the vitamin C content of the leaves is proportional to the intensity of light. The vitamin C content of leaves of several varieties of *Miscanthus sinensis* and *Desmodium racemosa*, which are adapted to various different climates, was studied: it was seen that there is no or very little difference between them in this respect.

**197. Some examples of the years storage of seeds.** (Japanese). Mantarô KONDÔ and Yasuwo KASAHARA. (P.C.S.S. J. 12, 1940, 21-24).

Seeds of certain species of agricultural plants enclosed within a sac were preserved together with  $\text{CaCl}_2$  as an exsiccator in a large box. The rate of germination after ten years was as follows:

*Raphanus sativus* 81.3-89.3%, cucumber 88%, another cucumber 58%, *Cucurbita Pepo* 54.8%, *Solanum Melongena* 36.8%, *Capsicum annuum* 47.3%, *Zea Mays* 74.8%, *Avena sativa* 88.5%. Rice grains imported from Italy were generally of poor germination, except one sample 61.5%. Rice grains imported from Spain 55.5-70.5%, except one sample 1.3%.

**198. On the fertilization in *Sargassum Horneri*.** Hiroshi KUNIEDA and Shunzo SUTO. (Jap. J. B. 11, 1940, 141-146, 2 pls.)

**199. Neue Beobachtungen über Protoplasmaströmung bei *Hydrilla verticillata*.** Seikan KUSUNOKI. (Cyt. 10, 1940, 539-544).

Frisches Material von *Hydrilla verticillata* wurde samt den Wurzeln in einer 10% Zuckerlösung enthaltenden PETRISCHALE gelegt und dann gelegentlich wurden die Blätter davon entnommen und in 10% Zuckerlösung beobachtet.

Es wurde vor allem festgestellt, dass der Zellkern durch die Protoplasmaströmung mitbewegt wird. Dieser Vorgang dauert ziemlich lange, z.B. 10 Tage nach den Beobachtungen Verfs. Es wurde oft beobachtet, dass die Protoplasmaströmung noch



dauert, nachdem schon der Zellkern abgestorben ist. Die Umkehrung der Rotationsrichtung findet bisweilen statt. Auch unter gewissen Umständen ging die rotierende Bewegung in eine pendelnde über.

**200. Behaviour of chromonemata in mitosis. IX. On the configurations assumed by the spiralized chromonemata.** Yoshinari KUWADA and Takesi NAKAMURA. (Cyt. 10 1940, 492-515, 12 text-figs.).

In the staminate hairs of *Tradescantia reflexa*, there are two types in the configuration assumed by the chromatid spirals in the telophase, the spiral configuration and the twisted configuration. In the resting stage, the configuration is commonly of intermediate type, but the nuclei with spirals of the twisted configuration and those with spirals of the spiral configuration also exist. In the twisted and intermediate configurations, the nucleus shows a diffuse structure, while in the spiral configuration it presents an aggregate structure, the chromosome territories being perceptible. It is observed that in water medium the twisted configuration is transformed into the spiral configuration.

In water medium, it is also observed that the prophasic nucleus is transformed directly into the resting nucleus without passing metaphase and anaphase, an "abbreviated mitosis" which may correspond with the case of the formation of the "restitution-nucleus."

In this paper, the "fine structure" of the nucleus is discussed, and also the problems of 1) the anaphasic or telophasic split, 2) the minor spirals, 3) the number of the chromonemata in the chromosome, 4) the spiralization type of the chromonema spirals, and 5) the optical sign of chromosomes are considered. Y.K.

**201. Studies on a *Fusarium* disease of soy bean pods.** Kegi LIU. (M.C.A., K.I.U. No. 47, 1940, 15-29, 2 pls. and 8 tables).

The disease is characterized by the formation of flesh- or salmon-coloured sporodochia on pods of soy beans; it is caused by a fungus morphologically identical to *Fusarium bulbigenum* CKE et MASS. var. *tracheophilum* (E. F. SMITH) WR., which is known in America to cause the blight of soy beans, by attacking its roots and stems.

For the reproduction the unicellular microconidia, 2-5-septate macroconidia, chlamydospores and sclerotia are formed.

Through artificial inoculation sporodochia are formed on pods, just as under natural condition, but also on dead stems, which is never the case naturally. Daylight tends to inhibit to some extent the germination of conidia and the growth of germ-tube, and it was observed that the inhibition diminishes in the former case with the lapse of time. When conidia are tested in water drops, they are able to germinate in air with 95% relative humidity, but dry conidia are not able to germinate even in air of 99% relative humidity.

For the germination of conidia optimum temperature  $\pm 24^\circ$ , though they are able to germinate between  $16-36^\circ$ .

**202. Weitere Untersuchungen über die pentaploiden *Triticum*-Bastarde XI.** Seiji MATSUMURA. (Jap. J. B. 11, 1940, 17-25, 1 Textabb. u. 8 Tab.).

**203. Chromosome studies on *Trillium kamschaticum* PALL. XII. The mechanism of crossing over.** Hajime MATSUURA (Cyt. 10, 1940, 390-405, 26 text-figs.).

According to the author's observation the paired chromatids of each meiotic chromosome in PMC of *Trillium kamschaticum* constitutes in early metaphase the



relational spiral system, but in later metaphase it changes to parallel system. This change begins at first from the distal as well as the proximal ends, and these processes proceed inwards along the arm and meet to one another, till the parallelization is completed. The author could observe several stages of the transition between the parallel and relational systems, where the paired chromatids are partly parallel and partly relational. This conversion will be not possible through the rotation of free ends of the chromatids, and is possible only through segmental exchange, i.e. the breaks and reunions between the chromatids at the twisting points in the spiral system. Since according to the author's so-called "neo-two plane" theory the chromatids of each chromosome are not sisters in  $\frac{2}{3}$  of cases, the breakage and reunion above indicated will lead to detectable crossing over.

What was stated above is the author's new hypothesis accounting for the origin of crossing over.

**204. Chromosome studies on *Trillium kamschaticum* PALL. VIII. On the mitosis-meiosis relationship.** Hajime MATSUURA and Tutomu HAGA. (Cyt. 10, 1940, 332-389, 17 text-figs.).

In *Trillium kamschaticum*, which was subjected to high temperature (20°) several abnormal types were seen concerning the PMC's division, viz. mitotic, supra-mitotic and ultra-mitotic. In the first of the above three types no pairing of chromosomes takes place just as in the mitotic division of root-tip cells, and 10 separate univalents appear in the metaphase instead of 5 bivalents, while in the second and the third 20 separate chromatids and 40 separate half-chromatids are observed respectively. Further, any of the three above types may be either precocious or standard. In the latter case the behaviour of the kinetochore is normal, while in the former it has already split further at metaphase and each chromosome consisting of two separate chromatids are found lying parallel within the pellicle and coiling separately.

Attempts have been made by previous authors to homologize the mechanism of meiosis with that of usual mitosis. Basing on the results of his investigations just mentioned the authors think that meiosis differs in its mechanism from the mitosis in the retardation of prophase, just in contrast to the precocious hypothesis of DARLINGTON.

**205. Biochemische Studien über die Zellmembran von Braun- und Rotalgen.** Tomoo MIWA. (Jap. J. B. 11, 1910, 41-127, 5 Textfig. u. 5 Tab.).

**206. On *Laminaria japonica* ARESCH. and *Laminaria angustata* KJELLM.** Kingo MIYABE. (P.I.A. 16, 1940, 155-156, 3 text-figs.).

O. C. SCHMIDT has transferred recently the two species of *Laminaria* cited in the above title to the genus *Pleurophyucus* SETCHELL et SAUND on account of the presence of longitudinal folds on the blade.

The author, on comparing the folds in *Laminaria* on one hand and those of *Pleurophyucus* on the other, comes to the conclusion that the folds in the former case are of quite different nature as those in the latter. Thus, for instance, two folds in *Pleurophyucus* are distinct even in dried specimens, while in the two species of *Laminaria* in question the folds disappear or become indistinct in dried specimens.

The author thinks therefore that it will be well to retain the two species in the genus *Laminaria*.

**207. Contributions to the flora of North Japan XIII.** (With Japanese résumé). Kingo MIYABE and Misao TATEWAKI. (T.S.N.H.S. **16**, 1940, 181-192, 1 pl.).

11 plants are enumerated, of which the following are new and provided with their respective diagnoses. *Viola Harae*, *Cortusa jozana* (a key for the identification of species and varieties of *Cortusa* in Northern Japan is given), *C. sachalinensis*, A. LOS. var. *congesta* var. nov., var. *yezoensis* var. nov., *C. sibirica* ANDRZ. var. *insularis* var. nov., *Primula Hisauchi*, *P. modesta* BISSET et MOORE var. *shikoku-montana* var. nov., *Sasa laminata*, *S. Yasokichii*.

All above are new species and varieties by MIYABE et TATEWAKI, except the last two, which are due to TOMIOKA et TATEWAKI.

**208. Studies on the gametophyte of ferns (XIII), (XIV), (XV).** (Japanese). Siduo MOMOSE. (J. Jap. B. **16**, 1940, 206-218, 9 text-figs.; 280-296, 6 text-figs.; 353-370, 10 text-figs.)

In the three papers above cited the prothallia of the following ferns are described: *Diplazium Wichurae* DIELS, *Polystichum japonicum* DIELS, var. *fibrilloso-paleaceum* H. ITÔ, *Ctenitis Maximowicziana* H. ITÔ, *C. shikokiana* H. ITÔ, *Rumohra aristata* CHING var. *typicum* H. ITÔ, *R. assamica* CHING, *R. nutica* NAKAI, *Dryopteris serrato-dentata* HAYATA, *D. melanocarpa* HAYATA, *D. Bissetana* C. CHRISTENSEN var. *typica* H. ITÔ, *D. chinensis* KOIDZUMI, *D. gymnophylla* C. CHRISTENSEN.

**209. The sterile mutant found in a certain strain of rape.** (Japanese). Toshitaro MORINAGA. (J.J.G. **16**, 1940, 72-74, 7 text-figs.).

In the fields where the strain of rape called Nôrin No. 3 was cultivated, the author has discovered a number of highly sterile mutants, amounting to 0.06-1.11% of the whole. The number of siliques per plant is 10 fertile and 0 sterile in normal plants, while in mutants it is 7.6 and 2.4 respectively. Seeds per silique are on the average 27.1 in normal, but only 0.18 in mutant plants.

Cytological studies have revealed the irregular meiosis of PMC. In I-metaphase a large number of univalents are seen, and in anaphase many lagging chromosomes are observed. The second division was often suppressed, so that dyads and pollen grains of large size are formed.

**210. Cytogenetical studies of *Oryza sativa* L. IV. The cytogenetics of  $F_1$  hybrids of *O. sativa* L. and *O. minuta* PRESL.** Toshitaro MORINAGA. (Jap. J. B. **11**, 1940, 1-16, 29 text-figs. and 4 tables).

**211. List of the chromosome numbers in the genus *Saccharum* and related genera.** Akira MORIYA. (J.J.G. **16**, 1940, 123-136).

An extensive list indicating the chromosome number of various species of *Saccharum* with the great number of their respective varieties. Data are compiled from numerous sources, and the literature is given.

**212. Studies on septorioses of plants VII. New or noteworthy species of *Septoria* found in Japan.** Nakato NAITO. (M.C.A., K.I.U., No. **47**, 31-43, 1 pl.).

The author enumerates 22 species of *Septoria* of plants, of which the following are new: *S. Omphalodis*, *S. Abei*, *S. Milletiae*, *S. Mazi*, *S. Lycoridis*, *S. Duchesneae*, *S. Justiciae*, *S. Carpesii*, *S. Ambrosiae*, *S. Celastri*, *S. Akebiae*.

**213. Notes on some new or noteworthy fungi of Japan.** Nakato NAITO. (M.C.A., K.I.U., No. **47**, 45-52, 4 text-figs.).

The following new fungi are described among others: *Phyllosticta Capsellae*, *P. Macleyae*, *P. Arunci*, *P. Akebiae*, *Ascochyta Cissi*, *Cercospora callicarpicola*, *C. Nanoenides*, *Macrophoma Nasturtii*.

**214. Iconographia plantarum Asiae Orientalis Vol. III, No. 3, Tokyo 1940.**  
Edited by Takenoshin NAKAI. 9 pls. and 34 pp.

This No. contains the illustrations and the descriptions of the following plants: *Colocasia Tonoimo* NAKAI (by NAKAI), *Paris arisanensis* HAYATA, *Neottia Nidus-avis* L. C. RICHARD var. *manshurica* KOMAROV (above two by Y. KIMURA), *Gymnosiphon Okamotoi* TUYAMA, *Gastrodia nipponica* TUYAMA (above two by TUYAMA), *Gastrodia confusa* HONDA et TUYAMA (by HONDA and TUYAMA), *Athyrium coreanum* CHRISTY, *A. unifurcatum* (BAKER) C. CHRISTENSEN var. *Okuboanum* (MAKINO) H. ITÔ, *A. viridifrons* MAKINO (above three by H. ITÔ).

**215. Notulae ad plantas Asiae Orientalis (XII)-(XIV).** (With Japanese résumé).  
Takenoshin NAKAI. (J. Jap. B. 16, 1940, 1-17, 1 text-fig.; 61-81, 121-138).

*Sasa* (*Eusasa*) *iburiensis*, *Androsace hopeiensis*, *Athyrium rigidulum*, *Scabiosa hopeiensis*, *Cirsium fusenense*, *C. Zenni*, *Ligularia hopeiensis*, *Arisaema Mayebarai*, *Cryptocarya Tsangii*, *Machilus Hemsleyi*, *Neolitsea chekiangensis*.

The above plants are new species of the author, and provided with their respective diagnoses. Besides, a large number of new varieties and new combinations are contained in the papers.

**216. A commentary on the Japanese *Euchresta*.** (English and Japanese).  
Takenoshin NAKAI. (J. Jap. B. 16, 1940, 243-254, 1 text-fig.).

In the genus *Euchresta* the author has created a new section *Parachresta*. Its typical plant is *Euchresta japonica* HOOKER fil. et BENTH. *E. Horsfieldii* BENTH. var. *formosana* HAYATA was raised by the author to the species rank under the new name *Euchresta formosana* NAKAI.

**217. Ueber die Photosynthese der Grünbakterie, *Chlorobium limicola* NADSON.**  
(Japanisch m. deutsch. Zfg.). Hiroshi NAKAMURA. (B.M.T. 54, 1940, 48-52).

Wenn man die Photosynthese der Grünbakterie, *Chlorobium limicola* mit derselben der Purpurbakterien, besonders *Chromatium* vergleicht, so wird man zwischen beiden eine nähere Uebereinstimmung erkennen. Bei beiden geht die Assimilation sehr lebhaft vor, wenn im Medium Fettsäure, H<sub>2</sub>S oder molekularer H vorhanden ist. Man kann den Reaktionsmechanismus der Photosynthese von beiden Bakterienarten als ganz gleich ansehen. Die nähere Untersuchung der Photosynthese von *Chlorobium* wird für die Zukunft vorbehalten.

**218. Induced polyploidy in Asiatic varieties of cotton plant by colchicine treatment.** (Japanese). Sadao NAKATOMI. (P.C.S.S.J. 12, 1940, 16-20, 5 text-figs.).

Seeds as well as young seedlings of cotton plant (Asiatic and upland types) were treated by 0.1 and 0.5% watery solution of colchicine.

Seeds treated with 0.5% solution died without any exception, while in seedlings treated with 0.1% solution 90% died away. In plants which survived after this treatment leaves were often more than doubled in their area than in normal ones and thickened; stems are also thickened and often fasciated. Flowers were very imperfect, and generally sterile.

Among Asiatic-typed cotton treated by 0.1% solution during 6 days the author has got one individual which has borne one capsule. In this plant the PMC contained 26 chromosomes (normally 13), so that it has proven itself to be a tetraploid. This individual is characterized by longer and wider cotton fibers, as well as heavier seeds than in normal case.

**219. The diatom-flora of the Nasu hot springs. (Preliminary report).** (Japanese with English résumé). Ken'itirô NEGORO. (B.M.T. 54, 1940, 63-65).

A number of diatoms collected in hot springs of Nasu were sent to the author for identification. This collection contained 18 kinds of diatoms, all of which were new to the hot spring flora of Japan. All species are indicated in a table.

**220. Some diatoms from Itibisinaiko, a mineralogenous acidotrophic lake in Kunasirizima of the Southern Kurile Islands.** (Japanese with English résumé). Ken'itirô NEGORO. (B.M.T. 54, 1940, 106-110, 3 text-figs.).

A number of microscopic organisms collected in the lake cited in the above title were sent to the author. The collection contained 3 kinds of diatoms, viz. *Pinnularia Braunii*, also its var. *amphicephala*, and *Eunotia septentrionalis*. Many abnormal species of *Eunotia* were found.

**221. Effects of fast neutrons upon plants II. Abnormal behavior of mitosis in *Vicia faba*.** Y. NISHINA, Y. SINORÔ and D. SATÔ, (Cyt. 10, 1940, 406-421, 46 text-figs.).

Young seedlings of *Vicia faba* were exposed to irradiation of fast neutrons obtained by the bombardment of beryllium target by 2.8 MeV deuterons from the cyclotron. The exposure was done in various ways, viz. the duration 20, 30 or 60 min., the distance of the material from the target 1-4 cm (strong treatment), 4-8 cm (medium treatment) and 8-12 cm (weak treatment) respectively. Root-tips of treated plants were fixed either immediately or 12-120 hrs. after irradiation.

The abnormalities were seen more or less abundantly, such as chromosome fragmentation, fusion of distal ends of separating chromosomes in anaphase, stray chromosomes, formation of chromosome bridges, etc., etc.

In the materials of weak treatment only few abnormalities were met with, but in those of medium and strong treatment they are more abundantly observed and were conspicuous.

The so-called primary effect of irradiation appears in materials fixed 0-24 hrs. after irradiation. It consists on one hand in the advancement of the mitotic process from the metaphase to the telophase, and on the other in the delay of the same mitotic process, owing to the chromosome aberration and relative advancement of chromosome formation from prophase to chromonemata. The former may be attributed to the effect on the cytosome and chromosome ("Entmischung" or vacuole formation, dehydration) and leads to the increase of telophasic figures. The latter may be attributed to the effect on the chromosomes, namely fragmentation, clumping, and hydration, and leads to the accumulation of mitotic figures in the metaphase and later stages.

The so-called mitotic-free period effect is observed on the materials fixed 24-72 hrs. after irradiation. This is due to the delay in chromosome formation from the resting nuclei.

The secondary effect is observed on the materials fixed more than 96 hrs. after irradiation, i.e. in those which have passed through the mitosis-free period just indicated. Here again the mitotic figures increase, and this may be attributed to the



recovery from the neutron bombardment effect. Various abnormalities were observed also in these materials.

**222. Effects of fast neutrons upon plants, III. Cytological observations on the abnormal forms of *Fagopyrum* and *Cannabis*.** Y. NISHINA, Y. SINÔTÔ and D. SATÔ. (Cyt. 10, 1940, 458-465, 3 text-figs.-groups).

Detailed description of the results published some time ago. (Cf. this JOURNAL 10, (58), No. 207).

**223. Studies on artificial polyploid plants III. Meiosis of tetraploid hemp.** (Japanese with English résumé). Ichizo NISHIYAMA (B.Z. 8, 1940, 47-52, 10 text-figs.).

For inducing polyploidy in *Cannabis sativa* the author proceeded as follows: the growing tip of young seedlings or their cut stems after decapitation were treated with a few drops of 0.2% colchicine solution. Three male plants of didiploid nature ( $2n=40$ ) were thus obtained. The five female plants, though they were not cytologically examined, are in all probability tetraploid, as inferred from the large size of their stomata and seeds. Further, in some seedlings which were decapitated and not treated with colchicine solution the chromosome doubling as well as the mosaic formation of di- and tetraploid tissues were recognized.

It is known that in *Cannabis sativa* the chromosome formula is  $18a+X+Y$  ( $\sigma$ ) and  $18a+2X$  ( $\varphi$ ), Y being much smaller than X. In tetraploids got by the author the chromosome formula is  $2n=36a+2X+2Y$ . The PMC contains usually 20<sub>II</sub>, XX and YY pairings being usually seen instead of XY. The autosomes form frequently the quadrivalents. Pollen grains are 98% good.

**224. Studies on artificial polyploid plants. IV. Comparative studies on 1x-4x-plants in *Capsicum annum* L.** (Japanese with English résumé). Ichizo NISHIYAMA. (B.Z. 8, 1940, 905-913, 9 text-figs.).

The treatment of seeds of a variety of *Capsicum annum* with 0.05-0.8% watery solution of colchicine for 72 hrs. has given rise to many tetraploids as well as the chimaera of di- and tetraploid tissues, and further to haploids and hypotriploids. The comparison of polyploid series has shown that in some respects the higher polyploids are more gigantic than the lower ones, thus, for instance, the growth habit, size of leaf, epidermal cells, stomata, flowers, pollen, seeds, etc., etc.

The haploid plant contains 12 chromosomes, which are irregularly scattered and never go to pairing. In the hypotriploid plant ( $3x-1$ ) the chromosomes form generally the bivalents, but in PMC the uni- and tri- and quadrivalents were often met with. In haploids and hypotriploids the greater majority of pollen are deformed (96% and 65% respectively); they are perfectly sterile, because either no fruits at all are formed or some produced at the close of flowering season are quite empty.

**225. Measurement of the size of bast-fibres. (I).** (Japanese). Yudzuru OGURA. (Spinning, March No., 1940, 15 pp.).

Concerning a number of Japanese fibre-plants (in total 98 families, 355 species) the length and breadth of bast-fibres (incl. sclerenchymatous fibres situated outside the ploom, those forming the sheath of the fibro-vascular bundles, etc.) were measured. The results—length and breadth (maximum and minimum) and the ratio, length: breadth are shown in an extensive table. Some of the general conclusions are as follows:

Fibres which were examined measure in average mostly 1-2 mm. in length and 0.01-0.02 mm. in breadth. Species similar to each other which belong to one family



or one genus resemble to each other in length and breadth of their fibres, though the exceptions are present. Climbing plants have generally larger fibres than the ordinary ones.

**226. Interspecific hybridization in *Nicotiana*. Breeding of the nicotin-free tobacco by hybridization *Nicotiana tabacum* × *N. glauca*. (Japanese). Hideto T. OKA. (J.J.G. 16, 1940, 87-88, 2 text-figs.).**

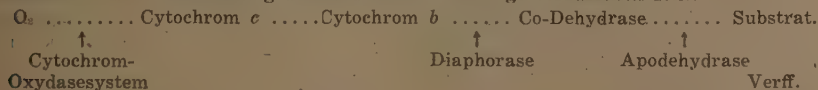
*Nicotiana glauca* which is arborescent, perennial and wild growing, is known as nicotine-free. *N. tabacum* ♀ × *N. glauca* ♂ is quite easily done, but since the  $F_1$  offspring are perfectly sterile no investigation of further generations has been hitherto done. The author has however obtained by means of back-crossing (*N. Tabacum* × *N. glauca*) × *N. Tabacum* two capsules containing 150 seeds which have given rise to 15 plants. The strain of *N. Tabacum* used by the author for his crossing experiment contains 1.764% nicotine, and its percentage in 15 hybrid plants got by him is various and lies between 0.1140 and 1.264. The chromosome number in *N. Tabacum* is  $n=24$  and that in *N. glauca*  $n=12$ , while that in 15 offspring is various and lies between  $2n=49-59$ .

**227. Notes on diatoms of Japan.** Haruo OKUNO. (J.S., H.U.I. 4, 1940, 37-72, 47 text-figs.).

In this paper a number of pennate diatoms belonging to several genera, species, varieties and forms are contained, many of them being new to the flora of Japan.

**228. Ueber die Rolle der Diaphorase in der Wechselwirkung zwischen dem Cytochrom *b* und dem Dehydasesystem.** Kazuo OKUNUKI und Eihiro YAKUSHIJI. (P.I.A. 16, 1940, 144-148, 3 Textfig., 3 Tab.).

Mit der von Diaphorase befreiten Cytochrom-Oxydase aus Rinderherzmuskel und dem von Cytochrom-Oxydase befreiten Diaphorase-Präparat aus Pollen bzw. der STRAUBSchen Herzmuskel-Diaphorase konnten die Verfasser dartun, dass das System Cytochrom-Oxydase + Cytochrom *c* + Cytochrom *b* + Diaphorase + Co-Dehydrase + Apodehydrase + Substrat stets eine bedeutend stärkere  $O_2$ -Aufnahme bewirkt als die Systeme mit fehlendem Cytochrom *c*, *b* oder Diaphorase. Am nächsten liegt hier die Annahme, dass die Diaphorase zwischen Cytochrom *b* und Co-Dehydrase eingeschaltet ist und die Oxydoreduktion zwischen diesen beiden Komponenten katalysiert. Der Mechanismus der Zellatmung dürfte demnach wie folgt vorzustellen sein:



**229. Vorkommen der triploiden Intersexe bei *Humulus japonicus*.** (Japanisch m. deutsch. Zfg.). Tomowo ONO. (B.Z. 8, 1940, 1632-1634, 2 Textabb.).

Unter den Nachkommen der nach der Colchicinmethode bekommenen Tetraploiden von *Humulus japonicus* befanden sich die Triploiden, nämlich, Weibchen und Intersexen, welch 25 somatische Chromosomen enthalten. In den letzteren sind die rein weiblichen und rein männlichen Blüten an ein und demselben Individuum vorhanden (monözisch), und in diesem Falle sind in jedem Blütenstand zuerst die weiblichen Blüten entwickelt und allmählich nach der Spitze hin beginnen die männlichen zu erscheinen.

**230. Experiments on chromosome doubling by acenaphthene treatment.** (Japanese with English résumé). Tomowo ONO. (B.Z. 8, 1940, 39-46, 6 text-figs.).

By treating bulb plants, such as *Allium Cepa*, *Scilla peruviana*, hyacinth and *Ornithogalum* with acenaphthene, the author has observed the swelling of the root end very near to the tip, and further, he could observe in the root-cells of *Scilla peruviana* besides the normal nuclei containing  $2n=16$  the tetraploid and almost octoploid nuclear plate.

By treating *Pisum sativum* with acenaphthene, not only did the author see the swelling of root end, but also he has got one tetraploid plant, which is characterized by larger stomata, epidermal cells, and pollen than usual. The self-fertilization of this plant has produced 6 seeds, which, on germination, have given rise to 4 tetraploids ( $2n=28$ ) and 2 hypertetraploids ( $2n=29$ ).

**231. Polyploidy and sex determination in *Melandrium* II. The effect of polyploidy upon sex in *M. album*.** (Japanese with English résumé). Tomowo ONO. (B.M.T. 54, 1940, 225-230, 1 text-fig.).

Individuals of *Melandrium album*, which were subjected to long-day treatment in a warm-house, came to flowering almost two months earlier than those placed under natural condition. The fertilization of the tetraploids among themselves as well as that of diploids by tetraploids and its reciprocal were performed. As the consequence of such procedures a number of plants with various combinations of chromosomes, somatic as well as sexual, were got. It was ascertained that the individuals bearing the X- and no Y-chromosome are always female, while those with the Y-chromosome are always male. Thus, for instance,  $2A+XX$ ,  $3A+XXX$ ,  $4A+XXXX$ , etc. are female ( $A$ =autosomes), and  $2A+XY$ ,  $3A+XXY$ ,  $4A+XXXXY$ , etc. are male. On the basis of the above observations it is quite clear that the sex-chromosome Y is directly concerned in the sex determination, in contrast to what we see in *Rumex* or *Drosophila*, where the sex is determined by the relative rate of the number of somatic and sex chromosomes, and the Y-chromosome itself has no direct relation with the sex determination.

The relation of poly- and heteroploidy on the size and form of corolla as well as the number of stigmatic branches is announced.

**232. Lichenes ab A. YASUDA et aliis in Japonia collecti (I)-(II).** Veli RÄSÄNEN. (J. Jap. B. 16, 1940, 82-98, 139-153).

Among 229 lichens enumerated in this paper the following new species are contained: *Umbilicaria japonica*, *Parmelia Yasudae*, *Cetraria daibuiensis*, *Ramalina Yasudae*, *Candelariella vitellina* (EHR.) MÜLL.-ARG. var. *Tsunodae* (YASUDA), *Haematomma dispersum*, *Placolecnora liukuensis*, *Lecanora iscana*, *L. rikuzensis*, *L. atro-lactea*, *L. Kozukensis*, *Aspicilia ochraceorubra*, *A. prorampens*, *A. mamillata*, *Pertusaria pachyplacoides*, *P. coreana*, *Protoblasteria Vakavae*, *P. amagiensis*, *P. subaurantiacum*, *Anaptychia hypocaesia* YASUDA, *Rinodina kozukensis* YASUDA, *R. Tsunodae* YASUDA, *Buellia soboënsis* YASUDA, *Lobaria buensis*, *Pannaria japonica*, *Collema shiroumanum* YASUDA, *Baeomyces soboënsis* YASUDA, *Cladonia macroptera*, *Bombyliospora subnigrata* YASUDA, *Porina aspera*, *Byssophyllum japonicum*, *B. isidiosum*, *B. sanguineum*.

**233. Beobachtungen über japanische Moosflora XXI-XXII.** (M. japan. Zfg.). Kyuichi SAKURAI. (B.M.T. 54, 1940, 5-11, 10 Textfig.; 167-177, 15 Textfig.; 199-200).

Die folgenden neuen Arten sind beschrieben: *Holomitrium nodosum* DIX. et SAK., *Rhacomitrium Doii* SAK., *Webera curiosa* DIX. et SAK., *Ptychomitrium viride* SAK., *Cirriphyllum semiteretifolium* SAK., *Ctenidium percrassum* SAK., *Ectopothecium nip-*

*ponense* SAK., *Hymnum Hosoi* DIX. et SAK., *Isopterigium boninense* SAK., *I. yezoanum* SAK., *I. rubro-tapes* SAK., *I. rubellum* SAK., *I. japonicum* SAK.

### 234. Vitamin B<sub>1</sub>-Synthese bei Mikroorganismen II-III. Ueber die Schimmelpilze II-III. Kyuya SAKURAI. (J.S., H.U. 4, 1940, 1-11, 2 Tabellen).

*Aspergillus niger*, *Penicillium glaucum*, *Mucor racemosus* und *M. mucedo* wurden im synthetischen Boden, welcher aus der Grundlösung (K<sub>2</sub>HPO<sub>4</sub> 0,5%, MgSO<sub>4</sub> 0,25%, FeCl<sub>3</sub> Spur, Glukose 5,0%) + anorganischen oder organischen Substanzen besteht, kultiviert. Die dabei entwickelten Pilzdecke wurden nach einiger Behandlung pulverisiert und zu den enthüllten Reis zugefügt. Die Bildung von Vitamin-B<sub>1</sub> durch jeden von den obengenannten Schimmelpilzen wurde durch die Vergleichung der Lebensdauer des mit dem obigen Futtermittel gefütterten Versuchstieres (Spatzenpapagei) mit der des Kontrolltieres, welcher mit dem das Vitamin-B<sub>1</sub> enthaltenden Futtermittel gefüttert sind.

Es wurde dabei gefunden, dass bei *Aspergillus niger*, welches in der Grundlösung mit Harnsäure oder Nuklein kultiviert ist, die Vitamin B<sub>1</sub>-Bildung recht bemerklich ist, aber bei demjenigen, welches in der Grundlösung mit Ammoniumnitrat kultiviert ist, sie keineswegs ebenso bedeutend ist.

*Mucor racemosus* kann nach den Experimentresultaten eine kleine Menge von Vitamin-B<sub>1</sub> ausbilden, mit organischen N-Quellen, während *M. mucedo* dazu fähig ist, weder mit organischer noch anorganischer N-Quelle.

*Penicillium glaucum* produziert eine für den Versuchstier giftige Substanz, und es ist dabei kaum möglich, die Vitamin B<sub>1</sub>-Bildung nachzuweisen. Wenn man ein Experiment ausführt, wobei das Vitamin von Säureton adsorbiert werden wird, kann man auch gar kein Vitamin nachweisen, sodass *Penicillium glaucum* dazu unfähig sein muss.

Bei *Aspergillus oryzae*, *A. niger*, *Mucor racemosus* und *M. mucedo* wurden die Kulturexperimente ausgeführt, um kennen zu lernen, ob der Zusatz von 4-Methyl-5-(β-

Hydroxyäthyl)-Thiazol, 
$$\begin{array}{c} \text{CH}_3 \\ | \\ \text{C} = \text{C} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{OH}, \\ | \quad | \\ \text{N} \quad \text{CH} - \text{S} \end{array}$$
 welches dem Vitamin-B<sub>1</sub> eigen-

tümlich ist, die Bildung der letzteren befördern kann. Bei *Aspergillus oryzae* und *Mucor racemosus* trägt dieser Zusatz zur Vitamin-B<sub>1</sub>-Bildung bei, wenn die Nukleinsäure in der Grundlösung vorhanden ist, während bei *A. niger* und *M. mucedo* es nicht der Fall ist.

Im Falle, wo Ammoniumnitrat als die N-Quelle verwendet wird, wurde es festgestellt, dass der Zusatz von Thiazol jedenfalls von keinem Nutzen in dieser Hinsicht ist.

Weiter hat 4-Methyl-5-(β-Oxyäthyl)-Thiazol selbst auf die Bildung von Vitamin-B<sub>1</sub> gar keine Wirkung.

### 235. East Asiatic lichens. (II)-(III). (With Japanese résumé). M. M. SATÔ. (J. Jap. B. 16, 1940, 42-46, 3 text-figs.; 172-177, 4 text-figs.).

The following new lichens are contained in this paper: *Pseudobacomyces* SATÔ gen. nov. (Cladoniaceae) incl. *P. insignis* (ZAHLB.) SATÔ, comb. nov. var. *curtipes* (ZAHLB.) SATÔ comb. nov., *Pilophoron nigricaula* SATÔ, sp. nov.

The following new sections of the genus *Pilophoron* were established, 1. *Nigricaulia* (Type *P. nigricaula*) and 2. *Eupilophoron* (Type, *P. aciculare* Nyl.).

**236. Systematic anatomy of the articulated corallines (I).** (Japanese with English résumé). Sôkiti SEGAWA. (J. Jap. B. 16, 1940, 219-225, 5 text-figs.).

In this paper the results of the author's anatomical studies on *Amphiroa rigida* LAMOUROUX collected in the Bonin Islands are described in detail. The purely descriptive character of the paper makes it impossible to give here a short comprehensible account of the data.

**237. Basikaryotype and its analysis.** Y. SINOTÔ and D. SATÔ. (Cyt. 10, 1940, 529-538, 1 text-figs.-group).

The term "basikaryotype" newly made out by the authors is applied to such a chromosome type, specific to individuals or groups, corresponding in number to the basic number, and viewed from the standpoint of the chromosome morphology. In the investigation of this kind the chromosome behavior in meiosis should be studied and the criterion of the homology of chromosomes is assumed to lie in the pairing of chromosomes. Such a method of investigation is called the basikaryotype analysis by the authors. The difference between the latter and the genom-analysis is as follows: the basikaryotype analysis originated in the karyotype, while the genom-analysis started from the hybridization as a premise.

Among few instances of the basikaryotype analysis given by the authors that concerning *Paeonia* ( $2n=10$ ) is, for example as follows: karyotype  $2L_1^t + 2L_2^t + 2M + 2S_1^t + 2S_2^t$  (L long, M medium, S short, t trabant), and basikaryotype  $L_1^t L_2^t MS_1^t S_2^t$ . An example of karyotype analysis in Aloineae is fully described.

**238. The cytomorphological effects of halogens and halogen-salts on plant cells.** (With Japanese résumé). Y. SINOTÔ and A. YUASA. (B.M.T. 54, 1940, 205-214+1).

Root-tip cells of *Vicia faba* were subjected to the action of watery solution of halogens and halogen-salts. The effects were the irregular mitoses, the vacuolization of the nucleus and cytoplasm, the appearance of a clear area around the nucleolus, the destruction of nuclear contents, and the rendering of chromatin substance unstainable.

The intensity of the effect of various halogens and halogen-salts was in the following order: Cl-water > Br-water; NaF > NaCl > NaBr > NaI; KF > KCl > KBr > KI;  $\text{CaF}_2$  >  $\text{CaCl}_2$  >  $\text{CaBr}_2$  >  $\text{CaI}_2$ ;  $\text{NH}_4\text{F}$  >  $\text{NH}_4\text{Cl}$  >  $\text{NH}_4\text{Br}$  >  $\text{NH}_4\text{I}$ .

The PMCs of *Chrysanthemum* sp. were more sensitive to Cl- or Br-water than the other tissues of that plant and the root-tip cells of *Vicia faba*.

**239. Physiological and cytological relations between colchicine and heteroauxine.** (Japanese). Yoshitaka SOYANO. (B.M.T. 54, 1940, 141-148, 5 text-figs.).

Decapitated seedlings of *Vicia faba* were treated with heteroauxine or colchicine solutions by dropping them on the cut surface. Hypertrophy at the neighbourhood of surface was observed in the case of heteroauxine, while such abnormality could not be induced in the case of colchicine, and an abnormal axillary bud was formed. Then an *Avena*-test was tried and showed that heteroauxine induced a negative curvature of coleoptile, while colchicine induced no such or even positive curvature. Lanolin paste with heteroauxine or colchicine was painted at the hypocotyle of *Helianthus*. In the case of heteroauxine distinct hypertrophy was observed at the treated position, but the growth of young bud was not disturbed, while in the case of colchicine both hypertrophy and disturbance of growth were induced.

D. SATÔ.



**240. On the hypertrophy in the root induced by several chemicals.** (Japanese). Yoshitaka SOYANO. (B.M.T. 54, 1940, 185-195, 3 text-figs.).

The roots of *Allium*, *Cannabis*, *Vicia* and *Avena* were treated with several chemicals, such as colchicine, acenaphthene, auramin, chloral hydrate, naphthalene, vanillin, heteroauxine, ethyl benzoic acid, potassium cacodylate and atoxyl. In these experiments hypertrophy of roots was observed by the treatment with various chemicals which induced abnormal mitosis. This hypertrophy is divided into two processes, that is, the primary hypertrophy in elongating region of the root and the secondary one in meristematic region which is attributed to the increase of cell volume accompanied by the polyploidizing of the chromosome number. The polarity of root resulting in the elongation growth of the cell is altered by the substances which disturbed the polarity of mitosis and the hypertrophy is induced by such chemicals. Contrarily speaking, various substances which change the polarity of cell growth do not always induce abnormal mitosis except several ones. It is suggested that hypertrophy is attributed to the chance of polarity as its cause and does not occur without the existence of plant growth hormone.

D. SATO.

**241. Physiological and cytological effects of auramin upon roots.** (Japanese). Yoshitaka SOYANO. (B.M.T. 54, 1940, 237-245, 3 text-figs.).

Hypertrophy of root (primary hypertrophy) was observed, when *Allium* roots were immersed in dilute solution of auramin (1/50000—1/100000). Various abnormal mitoses are induced by auramin treatment, but these abnormal phenomena are somewhat different from those induced by colchicine and acenaphthene, particularly in strong disturbance of phragmoplast formation in the case of auramin. The possibility of inducing polyploid cells is indicated by the presence of binucleate cells. By the occurrence of both hypertrophy and abnormal mitosis in root treated with auramin, it is suggested that the cause of these phenomena may be solved by monistic inference such as the change of polarity. Very rarely chromonema bridge was observed in the pollen mother cell of *Tradescantia*, of which the inflorescence stalk was immersed in auramin solution.

D. SATO.

**242. On the multipartite chromosome ring in *Cephalotaxus drupacea* SIEB. et ZUCC.** Yosinori SUGIHARA. (Sc. Rpts., T.I.U. 15, 1940, 13-18, 2 pls.).

The chromosome number in the PMCs of *Cephalotaxus drupacea* is 112. In the I-metaphase of their first division 12 bivalents are met with in certain cases, but generally besides a number of bivalents some multipartite chromosomes are observed, for instance,  $10_{II}+1_{(I)}$ ,  $8_{II}+2_{(I)}$ ,  $7_{II}+1_{(I)}+1_{(a)}$ ,  $5_{II}+2_{(a)}+1_{(a)}$ , 4 and 6 within the brackets denoting the number of associated chromosomes in one multipartite chromosome. The type of association of chromosomes is constant in each individual. Each multipartite chromosome forms either a ring or chain. The author thinks that it is the result of segmental interchange among the chromosomes.

**243. A list of chromosome numbers in Angiospermous plants IV.** Toranosuke SUGIURA. (P.I.A. 16, 1940, 15-16).

The author has counted the number of meiotic chromosomes in 56 species of Angiosperms belonging to 12 families. Especially concerning the genus *Campanula* a large number of species was examined in this respect: their chromosome number was found to be 8, 17 and their multiples. The chromosome number of all plants studied is shown in a list.

**244. Studies in the chromosome number in higher plants. IV-V.** Toranosuke SUGIURA. (Cyt. 10, 1940, 324-333, 37 text-figs.; 363-370, 27 text-figs.).



In all plants treated in the above two papers the formation of the partition-walls of PMC takes place through the furrowing mode. The chromosome number of certain plant families is announced, and the basic number of each family is discussed.

The number and the size of chromosomes in the first and second metaphase and anaphase are given in a list.

**245. Chromosome studies on Papaveraceae with special reference to the phylogeny.** Toranosuke SUGIURA. (Cyt. 10, 1940, 558-576, 42 text-figs.).

*Pteridophyllum racemosum* differs considerably in its external appearance, both morphological and anatomical, from the other Papaveraceae, and consequently it was considered sometimes even as a member of a new family Pteridophyllaceae. This fact is in agreement with its karyological aspect, because its meiotic chromosome number is 9 (derived probably from the basic number 3), which is never found in any other member of the Papaveraceae (except *Rochmeria*).

In the Papaveraceae some species are characterized by the basic number 4 and others by that 3. Thus, for instance, *Hypecoum procumbens* 8 (basic number 4), *Chelidonium majus* and *Glaucidium corniculatum* 6 (basic number 3). In *Rochmeria* there are two series marked by the basic number 3 and 4 respectively.

The author proposes the hypothesis that each of the following genera has been produced in early time by the crossing indicated below:

<i>Hunnemannia</i>	7 = (4+3) .....	Corydaloideae	$\left( \begin{array}{c} \text{Corydalis,} \\ \text{Dicentra} \\ \text{or allied} \\ \text{species} \end{array} \right) \times$	<i>Eschscholtzia</i>
<i>Bocconia</i> <i>Macleaya</i>	10 = (4+3+3) .....	Corydaloideae	$\left( \begin{array}{c} \text{Corydalis,} \\ \text{Dicentra} \\ \text{or allied} \\ \text{species} \end{array} \right) \times$	<i>Chelidonium</i>
<i>Fumaria</i> (Fumarioideae)	7 = (4+3) .....	Corydalis or allied species	$\times$	<i>Glaucium</i>
Papaveroideae	7 = (4+3) 11 = (4+4+3) .....	Corydaloideae	$\times$	Chelidonioideae

Whether the above hypothesis will hold or not, should await a further study.

For further details and the author's phylogenetic speculation based on the chromosome number relation of various species cf. the original.

**246. Studies on Formosan ferns 1.** (With Japanese résumé). Motozi TAGAWA. (A.P.T.G. 9, 1940, 87-96).

This paper enumerates among others the following new plants: *Botrychium formosanum*, *Polystichum gladipinnum*, *P. neo-lobatum* NAKAI var. *brevipinnum*. All are provided with diagnoses.

**247. The gametophytes, fertilization and proembryo of *Sciadopytis verticillata*.** Masato TAHARA. (Sc. Rpts., T.I.U. 15, 1940, 19-27, 1 pl.).

In *Sciadopytis verticillata* the body-cell of the pollen-tube divides into two cells of unequal size, of which the larger one functions as the sperm-cell, and the smaller one which finally degenerates is often seen near the latter.

The mode of endosperm formation differs somewhat from what is known in other Gymnosperms. A thin protoplasmic layer containing free nuclei is formed around the central cavity of the megaspore, and then the cell-wall formation begins to take place. The endosperm cells formed are not arranged regularly, and they contain sometimes more than two nuclei. The thin protoplasmic layer containing free nuclei

is present during the whole course of endosperm formation. A definite layer of cells remaining open towards the central cavity, as it is the case in many Gymnosperms, is not observed in *Sciadopytis*.

The ventral canal nucleus remains rarely intact for a long time. The author has observed the case when this nucleus is in direct contact with the egg nucleus laterally. This seems as though it were the sperm nucleus being in conjugation with the egg nucleus, but according to the author the conjugating sperm nucleus seems to come in contact with the egg nucleus only at its apex, and not at its side. Besides, 2, 4 or 8 supernumerary nuclei are found in the middle or the lower part of the archegonium, which are in all probability the products of the ventral cell nucleus.

The formation of the proembryo begins with six simultaneous nuclear divisions, followed by the cell-wall formation after the fifth nuclear division, i.e. after the formation of 32 free nuclei and it is completed after the sixth. Since even after the latter division some nuclei remain in resting stage, 64 definite nuclei are not counted. The number of cells in the lower part, embryo initial, is  $\pm 20$ , that in the prosuspensor 10-13 or more, the rosette cells 0-3, the free nuclei in the uppermost tier  $\pm 20-30$ .

**248. The development of the conceptacle of *Sargassum*.** (Japanese with English résumé). Masato TAHARA. (B.M.T. 54, 1940, 148-151, 2 text-figs.).

In *Sargassum enerve* and *Horneri* there is the initial cell of the conceptacle near the common apical cell of the thallus. The former divides itself into two cells, upper and lower by means of a curved wall, which is concave towards the upper one. The latter is the so-called the tongue cell. The lower cell undergoes longitudinal divisions repeatedly, and gives rise to the wall-cells lining the conceptacle cavity. Later the tongue cell becomes free from the wall of the conceptacle, and is transferred to its mouth. In *S. enerve* the tongue cell is covered with mucilage and closes up firmly the opening or mouth of the conceptacle, while in *S. Horneri* it is provided with no mucilage, but grows gradually to close up the mouth also firmly. Such behavior of the tongue cell will serve to protect the young dividing cells within the cavity, which are the origin of future sexual organs; the above is the mechanism, which has never been hitherto observed in any member of the Fucaceae, incl. even *Sargassum filipendula* studied by SIMONS.

**249. The effect of the temperature and the light conditions upon the germination of mulberry seed.** (Japanese with English résumé). Ichizo TAKAGI. (R.B., I.T.S.C. 2, 1940, 1-26, 1 pl. and 7 text-figs.).

The results of the author's experiments upon the germination of mulberry seeds executed since 1932 are described in this paper.

For the seed germination of mulberry, *Morus Lhou* (SER.) KOIDZ. the maximum, optimum and minimum temperature are 33-36°, 36-39°, and 18° respectively. In respect to light condition, even in darkness the seed germination may take place, provided the temperature will lie between 20° and 36°, though the germination rate is far inferior to that under red or dark-red light (through coloured glass plate). The germination is good under the light rays which have passed through red or orange plates or LIFA's dark red, orange, or yellow filter, and then sometimes it is even better than under diffuse white light (within MEISCHKE's "Förderbezirk" of spectrum, 7000-6800 Å, 5600-5200 Å), but it is extremely poor under the light rays, which have passed through the LIFA's violet or bluish violet filter, or through indigo glass plate (within MEISCHKE's "Hemmungsbezirk" of spectrum, 5800-5400 Å and 5000-3250 Å). It may

be remarked that even seeds which did not germinate under indigo or violet rays will come soon to germination, if transferred to white or dark-red light.

Another remarkable fact is that seeds can germinate quickly even under inhibitory indigo rays, if they are previously soaked in dilute sodium nitrate solution for 24 hrs. This fact will confirm the hypothesis of GASSNER that the chemical action of light upon the germination may be substituted by that of nitrogen compounds.

**250. On the plasmolysis form in *Allium cepa* with special reference to the influence of potassium ion upon it.** Noboru TAKAMINE. (Cyt. 10, 1940, 302-323, 14 text-figs.).

There are several plasmolysis forms, of which the two chief ones are the convex and the concave form, besides the tonoplast and the cap plasmolysis, etc. The convex plasmolysis will take place generally if the cytoplasm is of low viscosity (low cohesion) and adheres weakly to the cell-membrane, while the concave plasmolysis with its stretched fine fibres between the cell-membrane and the cytoplasm, will occur, if the latter is of high viscosity (strong cohesion) and adheres firmly to the cell-membrane.

Plasmolytic experiments executed by the author on the epidermal cells of bulb-scales of *Allium cepa* will be briefly summarized below.

In 0.6 and 1 mol solution of saccharose the plasmolysis begins to take place on the corner of the cell, and appears soon as the concave form with stretched fibres, but after a certain time duration (plasmolysis time) it turns into a convex form. In 1 mol solution, however, the concave plasmolysis begins to appear more slowly, and the plasmolysis time lasts longer than in 0.6 mol solution.

When a hypertonic solution of KCl is used as the plasmolyticum, it is generally believed that the plasmolysis time is very short (at most 1-2 hrs.), but the author could hold it much longer, e.g. 3 hrs. or more. He thinks that the form and time of plasmolysis are variable according to the preservation mode of material and the external condition during the experiment. The influence of pH of the KCl solution used as the plasmolyticum, light, temperature, humidity, etc. on the plasmolysis form and time was studied. So, for instance, it was observed that the plasmolysis time is much shortened by illumination, which is in agreement with the fact that the light increases the permeability of cytoplasm.

Ca<sup>++</sup> and Al<sup>+++</sup> act antagonistically towards K-ion in relation to plasmolysis, for they prolong considerably the plasmolysis time. To cite one concrete example, KCl (0.5 mol) 36.9%, CaCl<sub>2</sub> (0.3 mol) 100%, KCl (0.5 mol) 95 parts + CaCl<sub>2</sub> (0.3 mol) 5 parts 76.7%. The above percentage denotes respectively the occurrence of concave form 30 min. after putting the materials in each of the three plasmolysing solutions above indicated. It will be seen thus that the plasmolysis time is shortest in KCl, longest in CaCl<sub>2</sub>, and intermediate in their mixture solution.

Finally the author has repeated the experiments of CHOLODNY and SANDKEWITCH, and obtained some results which are contrary to that of the latter author, which, as the present author thinks, might be based on the insufficient observation.

**251. Studies on the influence of ultraviolet rays on the cytoplasm, tested by the plasmolysis method.** Noboru TAKAMINE. (Cyt. 10, 1940, 577-587, 10 text-figs.).

The cells of the inner epidermis taken off from the scale-leaves of *Allium cepa* were exposed to the action of ultraviolet rays (100 volts and 3 amperes, distance 20 cm., duration 45 min.), and the feature of plasmolysis was studied. According to the author's view, various features of plasmolysis seen in the experiments may be explained by the assumption of the competition between the cohesion (viscosity) of the cytoplasm and

its adhesion to the cell-membrane. In cells exposed to ultraviolet rays and treated with various plasmolytica, e.g. saccharose, KCl, NaCl,  $\text{CaCl}_2$ ,  $\text{MgCl}_2$ , etc. there appear such features, as the formation of cytoplasmic particles and the tonoplast plasmolysis, both of which mean the disorganization of the cytoplasm; and this indicates the increase of the adhesion between the cytoplasm and the cell-membrane by the action of ultraviolet rays.

The ions or molecules, which are believed to penetrate easily into the cytoplasm,  $\text{NH}_3$  or  $\text{NH}_4\text{OH}$ , facilitate the destructive process, for instance, the occurrence of tonoplast plasmolysis, when its salt, as  $\text{NH}_4\text{Cl}$ , is used as the plasmolyticum.  $\text{Al}^{3+}$ -ion, however, which acts to raise the adhesion in the exposed cells, does not so act, as to separate suddenly the cytoplasm from the cell-membrane, when used as the plasmolyticum, so that its action serves more or less as a protection against the destruction of the cytoplasm.

**252. On the meiosis of *Rumex acetosa* L. treated with colchicine.** (Japanese with English résumé). Yô TAKENAKA. (B.M.T. 54, 1940, 12-23, 13 text-figs.).

In *Rumex acetosa* treated with colchicine the behaviour of PMC and pollen was studied. The results are briefly as follows:

The PMCs derived from the archesporium affected by this treatment were found to be tetraploid, though in I-metaphase no tetravalent chromosomes were seen, and the nuclear plate consisted chiefly of bivalents with some univalents. In the same material it is remarkable that the number of X-Y-complexes is greater than that of the X-X-ones.

In the first division of treated PMC no so-called c-bivalents are visible, and the univalents were seen scattered all over the cell. In the first and second division various irregularities were observed, the results of which were polynucleated cells or asymmetrical polyads. The giant cells carrying a large number of small chromosomes 30-150 were found among young grains.

Pollen is various in size. The pollination with pollen containing many large grains has given rise to the plants producing large seeds, and that with pollen containing many large grains to those producing small seeds.

**253. Chromosome studies in the genus *Acer*. L. (A preliminary note).** (Japanese with English résumé). Senji TAKIZAWA. (J.J.G. 16, 1940, 18-22, 18 text-figs. and 2 tables).

9 species of the genus *Acer* were examined in respect to the number of chromosomes, and in all cases examined by the author  $n=13$  and  $2n=26$  were counted. The PMCs behave quite regularly in meiosis ( $13_{II}$ ), except one single species *Acer japonicum*. The secondary pairing of chromosomes was observed in all species studied, and the maximum pairing type consists of 3(3 bivalents in association)+2(2 bivalents, in association), making 5 chromosome-groups in all.

In *Acer japonicum* var. *typicum* 2-6 bivalents as well as chromosome fragments were usually observed.

**254. Ueber das Wachstum von *Aspergillus oryzae* bei Zugabe der Aminosäuren als alleinige Kohlenstoff- und Stickstoffquelle.** Hiroshi TAMIYA und Shoichiro USAMI. (A.P. 11, 1940, 261-298).

Diese Untersuchung stellt eine Fortsetzung und Erweiterung der früher von TAMIYA ausgeführten Arbeiten über die Stoff- und Energiebilanz des Wachstums-



vorgangs von *Aspergillus*. Diesmal wurde der Pilz auf verschiedene Aminosäuren gezüchtet, die gleichzeitig sowohl als C- wie auch, als N-Quelle dienen sollten. Zur Anwendung kamen 14 Arten der Aminosäuren, deren Verwendbarkeit in Bezug auf Pilzwachstum bzw. auf -Atmung wie folgt ausfiel.

Verwendbarkeit zum Wachstum (Deckenkultur):

Isoleucin>Alanin, Leucin>Glutaminsäure>Arginin, Phenylalanin, Histidin, Tryptophan, Valin, Prolin>Glykokoll, Serin, Asparaginsäure>Lysin,

Verwendbarkeit zur Atmung:

Alanin>Isoleucin, Phenylalanin, Tryptophan>Leucin, Serin, Valin>Prolin, Histidin, Glykokoll>Arginin, Glutaminsäure>Asparaginsäure>Lysin.

Bei allen untersuchten Aminosäuren wurden als hauptsächliche Abbauprodukte  $\text{NH}_3$  und  $\text{CO}_2$  nachgewiesen. Während bei Histidin, Tryptophan, Prolin, Phenylalanin, Leucin und Isoleucin keine anderen Stoffwechselprodukte als  $\text{NH}_3$  und  $\text{CO}_2$  ausgeschieden zu werden scheinen, wurde bei Arginin daneben noch eine beträchtliche Menge von Harnstoff angehäuft gefunden. Bei Glykokoll, Alanin und Glutaminsäure schien vielleicht neben beträchtlichen Mengen von  $\text{NH}_3$  und  $\text{CO}_2$  eine kleine Menge der Oxydationsprodukte gebildet zu sein, deren Natur aber zur Zeit noch unbekannt bleibt. Im Grossen und Ganzen wurde auch für den Fall des Aminosäureumsatzes die befriedigende Gültigkeit der RQ-Theorie von H. TAMIYA bestätigt. Ausserdem wurde hierbei aufs neue gezeigt, dass man durch Erweiterung dieser Theorie die durch Atmung und Wachstum aus Aminosäuren freiwerdende  $\text{NH}_3$ -Menge vorausberechnen kann. Die Grösse des stofflichen sowie des energetischen Ausnutzungsgardes des Wachstumsvorgangs wurde theoretisch indirekt ermittelt, wobei sich ergab, dass sie, im Gegensatz zu den Angaben anderer Autoren, je nach den Arten der verwendeten Aminosäuren in weiten Grenzen verschieden ausfällt. Auf Grund der Ergebnisse der Bilanzanalyse wurde die Wärmetönung des Wachstumsvorgangs rechnerisch ermittelt, und es wurde dargetan, dass auch hier—wie es früher bei Kultur auf nicht N-haltigen C-Quellen gefunden wurde—der Vorgang des Pilzwachstums an und für sich eine exotherme Reaktion darstellt.

TAMIYA.

**255. Chromosome studies in Cyperaceae, VI. Pollen development and additional evidence for the compound chromosome in *Scirpus lacustris* L. Nobunori TANAKA. (Cyt. 10, 1940, 348-362, 30 text-figs.).**

The observations contained in this paper refer to the pollen development of *Scirpus lacustris* var. *typicus*. In this plant the nucleus of each PMC contains 38 chromosomes, of which 36 are small normal ones and the remaining 2 are large and correspond to the author's compound chromosome (cf. this JOURNAL 9, (173), No. 597 and 10, (67), No. 241). The I-metaphase of pollen development is normal, and 18 bivalents and 1 compound chromosome are observed. In I-anaphase and telophase, the behaviour of small chromosomes is normal, but that of the compound chromosome differs generally somewhat from the rule. In the anaphase the latter will mostly behave as the laggard, and in the telophase it forms mostly a chromatin bridge, which is sagittate-shaped and shows always more than one fiber attachment. Later its behaviour is perfectly normal until the time of pollen formation.

Three nuclei out of four (quartet) in each PMC will form the micronuclei in the Cyperaceae in general, but in *Scirpus lacustris* they undergo the division to degenerate finally. The remaining one nucleus, i.e. that of the pollen grain divides itself into a vegetative and a generative one, and then the generative cell is developed by means of the union of the phragmoplasts, which appear at first in the center of the telophasic spindle of the primary pollen nuclear division.



**256. Fragmenta florae micronesiae.** (With Japanese résumé). Takasi TUYAMA. (J. Jap. B. **16**, 1940, 194-205, 3 text-figs.).

Among 10 species enumerated in this paper the following new species are described: *Spathiphyllum funereum* (Araceae), *Drypetes Nakaiana* and *D. yapensis* (Euphorbiaceae).

**257. On genus Haloragis and Micronesian species.** (Japanese with English résumé and Latin diagnoses). Takasi TUYAMA. (J. Jap. B. **16**, 1940, 273-285, 6 text-figs.).

At first the history, distribution, etc. of the genus *Haloragis* are given. The following one new species and one variety of *Haloragis* from the Caroline Islands, Micronesia, are described in detail, and according to the author the following new species is intermediate between subsec.Trachycalyx and subsec.Laptocalyx, and consequently both sections should be united: *Haloragis palauensis* TUYAMA sp. nov. Further, *H. chinensis* (LOUREIRO) MERRILL var. *yapensis* TUYAMA var. nov.

**258. On the spindle figure of the somatic mitosis in the prothallium cell of Osmunda japonica THUNB. in vivo.** (A preliminary report). (Japanese with English résumé). Bungo WADA. (B.M.T. **54**, 1940, 89-96, 1 pl. and 1 text-figs.-group).

The young prothallium cells of *Osmunda japonica* were studied in respect to the somatic mitosis as a material very suitable for the study of the spindle figure.

In the late prophase the nuclear cavity is occupied by chromosomes ( $2n=44$ ) and atractoplasm derived from the karyolymph, while outside the nuclear cavity active cytoplasm is present. During the transition of prophase into metaphase the spherical nuclear cavity becomes gradually fusiform. It is to be remarked that the nuclear content is clearly separated from the surrounding cytoplasm. The often expressed view, that on fixed materials at that stage the nuclear content and the cytoplasm are mixed up, owing to the disappearance of the nuclear membrane, is perhaps the error founded on the result of artefacts caused by fixation.

In the metaphase and even in the telophase the spindle figure acts in its form and function quite independently from the surrounding cytoplasm. In telophase it appears as the phragmoplast. The cell-plate grows laterally in the latter and develops into a cell-wall, beginning from the point of contact with the mother cell-membrane. After the completion of the latter the cell-wall residue of the phragmoplast substance assumes the cytoplasmic nature, and is absorbed into the cytoplasm.

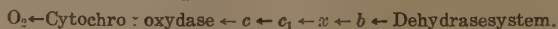
**259. A new species of fresh-water Rhodophyceae, Nematolopsis tortuosa nov. sp.** (Japanese with English résumé). S. YAGI and Y. YONEDA. (A.P.T.G. **9**, 1940, 82-86, 2 text-figs.).

The genus *Nematolopsis* SKUJA contained hitherto only one single species, *N. Shawi* SKUJA from the Philippines. The authors have discovered a second species of this genus in a certain locality of the province Iyo in Sikoku. It is called *N. tortuosa* YONEDA et YAGI sp. nov. It is described with illustrations.

**260. Ueber eine neue Cytochromkomponente und ihre Funktion.** Eijiro YAKUSHIJI und Kazuo OKUNUKI. (P.I.A. **16**, 1940, 299-302, 1 Textfig.).

Verff. haben in Herzmuskel eine neue Cytochromkomponente, das Cytochrom  $c_1$  (reduzierte Banden bei 552  $m\mu$  und 522  $m\mu$ ) aufgefunden und konnten dies mit Cholsäure extrahieren. Es wurde die Reduktion der Cytochromkomponenten durch Succinodehydase und ihre Oxydation durch Cytochromoxydase, bei den durch verschiedene Methoden dargestellten Herzmuskelbrei untersucht. Die Ergebnisse sind

wie folgt zusammenzufassen: Die Rangordnung der Cytochromkomponenten nach der Potentialhöhe ist  $-a-c-c_1-b-$ . Die Komponenten  $a$ ,  $c_1$  und  $b$  werden nur über die  $c$ -Komponente durch Cytochromoxydase oxydiert. Das Cytochrom  $a$  wird durch Succinodehydrogenase über die  $b$ - und  $c_1$ -Komponente, auch in Abwesenheit von  $c$ -Komponente, reduziert werden. Das Cytochrom  $c$  kann das Cytochrom  $a$  oxydieren, wenn die Oxydase voll aktiv ist. Ist dagegen die Oxydase inaktiv, so kann das Cytochrom  $a$  durch das Cytochrom  $c$  reduziert werden. Das Cytochrom  $c$  und  $c_1$  reagieren oxydoreduktiv unmittelbar mit einander. Vff. nehmen übrigens das Vorhandensein eines etwaigen Bindegliedes ( $x$ ) zwischen  $b$ - und  $c_1$ -Komponente an und haben folgendes Schema der Zellatmung vorgeschlagen.



Verff.

**261. Ueber die Wirkung verschiedener Pufferlösungen auf die *Spirogyra*-Zellen.**  
G. YAMAHARA und N. SUITA. (Cyt. 10, 1940, 371-381, 8 Textabb. u. 17 Tab.)

Die Verff. haben den schädigenden Effekt verschiedener Pufferlösungen auf die *Spirogyra*-Zellen untersucht, nämlich,  $KH_2PO_4 + K_2HPO_4$ , Na- bzw. K-Azetat+Essigsäure, Mono-K-Zitrat+KOH und Mono-K-Phthalat+KOH. Dabei beträgt der pH-Wert 4,0-9,0, und die Lösungskonzentration 0,001-0,05 GM. Solche Pufferlösungen bedingen verschiedene Strukturanomalien, nämlich, die Störung der spiraligen Anordnung der Chloroplastenbänder, ihre Trennung aus dem Wandbelag des Zytoplasmas, ihre Kontraktion, ihr Zusammengezogen unter Wirkung ihrer spiraligen Anordnung, und schliesslich ihre Disintegration bis zum tropfigen Zerfall oder Quellung. An dieser schädigenden Wirkung nehmen sowohl H- und OH-Ionen als Anionen teil; ihrer Effekt wird durch Ca- und Mg-Ionen vermindert (Entgiftung). Relative Wirksamkeit verschiedener Pufferlösungen von demselben pH geht mit der quellenden Wirkung der Gelatinalgallerte in Parallele, ausgenommen das Phthalat, d.h. Wirksamkeit der Anionen: Zitrat>Phosphat>Azetat>Phthalat; Quellungsreihe: Phthalat>Zitrat>Phosphat>Azetat.

Bei Phosphat- und Zitrat-Pufferlösungen beobachtet man, dass die Anionen der Pufferlösungen der quellenden Wirkung von OH-Ionen entgegengewirken, sodass die höhere Konzentration der Pufferlösungen gleichsam die Erniedrigung der pH derselben wirkt.

Schliesslich wird es festgestellt, dass die  $SO_4$ -Ionen die *Spirogyra*-Zellen schwer plasmolysierbar machen und somit die Chloroplastenkontraktion verursacht.

**262. Plant communities developed on the lava flow of Sakurazima.** (Japanese with English résumé). Tomozi YAMAKAWA and Masao NAKAMURA. (E.R. 6, 1940, 103-124, 6 text-figs. and 12 tables).

Sakurazima Volcano is known to have repeated several times its eruption since ancient times. The most recent eruption has taken place in 1914. The eruptions in 1475 and 1779 have done much damage owing to the terrible lava flow. The author compares in this paper the plant communities developed on lava flow of the two last eruptions just cited. Thus, in both plant communities, which show the same physiognomy, the dominant plant is *Pinus Thunbergii*. The layers of undergrowth and the ground flora are quite different in them. The number of plant species is far greater in lava flow of 1475 than in that of 1779, which may be due to the maturity of soil, since the acidity and water content have increased in older lava. If the growth of *Pinus* in these two lava flows is compared to each other by consulting the respective yield table, it will be seen that the growth of trees is far better upon older than newer

lava flow, which will indicate that even lava will become a good soil in the progress of time.

**263. An intergeneric hybrid in Saccharomycetes.** *Zygosaccharomyces saké* TAKAHASHI  $\times$  *Saccharomyces shaoshing* TAKAHASHI. (Japanese). Yukio YAMAMOTO. (B.Z. 8, 1940, 92, 1 text-fig.).

In respect to the hybridization, *Zygosaccharomyces saké*  $\times$  *Saccharomyces shaoshing* the author has got the success only in one out of forty cases. The ascospore of one species which was isolated was cultivated on a suspended drop of malt sap, together with that from another, and the two were placed near to each other. After 8 hours each ascospore produced the process, and soon after a zygote was produced by the fusion of the two processes. Afterwards the zygote produced two buds successively. Such buds, when placed on suspended drop of malt extract, did not reproduce and soon died, neither did the zygote produce buds further.

**264. Ueber den positiven und negativen Phototropismus von Laubblättern der *Fatsia japonica* im Zusammenhang mit den Wuchsstoffen.** (Mit japan. Zfg.). Gingoro YAMANE. (B.M.T. 54, 1940, 117-129, 7 text-figs. und 7 Tab.).

Früher hat der Verf. bei seiner Untersuchung über die Verteilung der Wuchsstoffe in phototropisch reagierenden Laubblättern von *Fatsia japonica* die aus dem Mutterstock ausgetrennten Laubblätter benutzt (vgl. diesen JOURNAL 9, (182), Nr. 625, ibid. 10, (74), Nr. 261). In der vorliegenden Arbeit sind die gleichartigen Versuche beschrieben, wobei die intakten Blätter der Topfpflanzen als das Material dienten. Die bekannte WENTS Agardiffusionsmethode durch *Avena*-Test wurde angewendet.

Die Verteilungsweise der Wuchsstoffe an den Schatten- bzw. Lichtseite stimmt völlig mit dem, was früher der Verf. festgestellt hatte, überein, d.h. bei dem positiven Phototropismus mehr Wuchsstoffe an der Schatten- als an der Lichtseite und bei dem negativen gerade umgekehrt. Das Verhältnis der Wuchsstoffe auf beiden Seiten (S:L, d.h. Schatten-: Lichtseite) ist im ersteren Falle 60: 40 und im letzteren 30:70.

Das Alter des Blattes muss bei diesem Phänomen in Betracht gezogen werden: die obengenannte geringe Menge der Wuchsstoffe an der Schattenseite (negativer Phototropismus) tritt meistens in den jungen Blättern, besonders unter starker Beleuchtung. Die älteren Blätter reagieren fast ausschliesslich positiv, wobei mehr Wuchsstoffe in der Schattenseite vorhanden sind. Bei den Blättern vom mittleren Alter, welche unter einer bestimmten Lichtintensität sich indifferent verhalten, ist das Verhältnis S:L fast 50:50.

Obgleich die Differenz der Wuchsstoffmenge an beiden Seiten der Laubblätter eine bestimmte Krümmung des Stieles verursachen wird, ist der Effekt je nach verschiedenen Blattindividuen nicht ganz gleich, indem einige einer grösseren Differenz bedürfen werden als die anderen mehr empfindlichen, um eine ganz gleichstarke Krümmung des Stieles ausführen zu können. Weiter sieht man, dass die in Rede stehende Differenz weit grösser ist bei dem negativen als bei dem positiven Phototropismus.

**265. Polyploid kowliang (*Andropogon sorghum*) induced by colchicine.** (Japanese with English résumé). M. YAMASAKI, M. NAKAMURA and A. MORIYA, (A.H. 15, 1940, 641-646, 2 text-figs.).

The treatment of young seedlings of kowliang (*Andropogon sorghum*) ( $n=10$ ) by colchicine has given rise to tetraploid plants ( $n=20$ ). The latter are characterized by possessing large stomata, and their pollen grains are somewhat poor in fertility, but otherwise no clear distinction can be drawn between the di- and the tetraploid. The

sectorial chimaera containing large and small stomata in leaves and also that containing different number of chromosomes were obtained.

**266. Cytogenetic studies in artificially raised interspecific hybrids of *Papaver* IX. On the bivalents-associations in the meiosis of the PMC of *Papaver somniferum*.** Kono YASUI. (Cyt. 10, 1940, 551-557, 6 text-figs.).

Concerning a race of *Papaver somniferum* 11 bivalents are seen in the diaphase of PMC. Such bivalents include, besides closed or open rings, just as in another race, side by side and end to end unions. So-called bivalents-associations were seen, which consist of two pairs of ring bivalents or one pair of side by side bivalents, or of a ring and an end to end bivalent. Such associations will separate from each other in the metaphase, though not always.

The derivation of the race of *Papaver* under discussion containing 11 bivalents is supposed to be as follows: the hybridization between 2 species having 4 and 3 chromosomes respectively has led to the formation of the amphidiploid individual  $2(3+4)=2(7)$ . The latter was crossed with a plant having 4 haploid chromosomes, thus making an amphidiploid  $2(7+4)=2(11)$ .

**267. On the spore and embryo-sac formation with special reference to the sterility of *Iris japonica* THUNB.** (Japanese with English résumé). Kono YASUI and Nobu SAWADA. (B.M.T. 54, 1940, 96-102, 21 text-figs.).

In the ovules of *Iris japonica*, which is an allotriploid, there are, beside 13.2% with normal embryo-sacs, 39.2% with incompletely developed and 32.2% with abnormal ones. Consequently at least 86.8% of the ovules are sterile. As to the pollen grains 65.4% were found to be viable.

Some ovules were seen to possess two or three megaspore mother-cells which are arranged side to side or end to end in the nucellus. They are considered to be unable to develop into twin or polyembryo.

**268. On the capsule formation, a rare case, with special reference to the sterility in *Iris japonica* THUNB.** (Japanese with English résumé). Kono YASUI and Nobu SAWADA. (B.M.T. 54, 1940, 135-140, 6 text-figs.).

Though *Iris japonica* may produce some capsules after the transplantation, they are never borne in subsequent years. The ratio of the number of ripe capsules to that of flowers is only 0.008%, which is very small, when man takes into consideration the number of viable pollen grains and normal embryo-sacs (cf. No. 267). According to the writers' view this may be due to the well-known vigorous vegetative development of the stolons.

**269. Cyanophyceae of Japan V.** Yûichi YONEDA. (A.P.T.G. 9, 1940, 39-48, 2 text-figs.-groups).

12 genera and 26 species and varieties of the Japanese Cyanophyceae are described, of which *Lyngbya subcapitata* is new.

**270. Ecological studies on the vegetation of pasture. 1. Semi-natural pasture of Mt. Hakkoda.—2. Pasture forest on Mt. Hakkoda.** (Japanese with English résumé). Y. YOSHII, H. YOSIOKA and E. IWATA. (E.R. 6, 1940, 25-48, 5 text-figs., 125-145).

The following abstracts are chiefly taken from the authors' own summary.

Ad 1.—The semi-natural pasture land Kayano, 550 m. above sea level, on the eastern slope of Mt. Hakkoda, was studied in ecological respect. Formerly this land was the forest of deciduous trees, dominated probably by the beech-trees and covered



with a tall turf, chiefly consisting of *Miscanthus sinensis*. From some ten years ago it was devoted to grazing, and consequently it was changed into a turf of short grasses, dominated by *Zoysia japonica*, though in less dry ground there are many tall plants, of which *Pteridium aquilina*, *Agrimonia japonica*, *Rubus parvifolia*, *Senecio palmatus* are non-palatable to the cattle. The comparison of such grazed lands with fenced lands nearby will indicate that if the lands under discussion would be left untouched for some time, palatable plants, such as *Miscanthus sinensis*, *Spodiopogon cotulifer*, *Lespedeza bicolor* var. *japonica* might develop there and it will become excellent pasture lands.

Ad 2.—In a beech wood, which is not devoted to grazing and deeply shaded, there are very few undergrowths and poor ground flora, except *Sasa kurilensis* which can endure deep shade and consequently there prosper. When, however, such forest is devoted to grazing, *Sasa kurilensis* will be eliminated within a few years, and then numerous young seedlings of beech will develop among others. If, however, their leaves and young sprouts are eaten by the cattle, the beech reproduction will be seriously prevented. On the contrary, if the beech-trees are cleared away to make the pasture, the invasion of palatable vegetation takes place, and then the beech stand will be gradually changed into a grassland. In all it will be seen that moderate grazing is favourable for the forest reproduction as well as for forest usage as a pasture.

**271. Studies in the cytology of Pteridophyta. XIX. The structure of the chloroplast of some pteridophytic plants observed on fixed and stained materials.** (Japanese with English résumé). Akira YUASA. (B.M.T. 54, 1940, 215-222 1, 4 text-figs.-groups).

This paper contains the results of the study of the structure of the chloroplast on fixed and stained materials in contrast to the previous paper of the author concerning the study on living materials (cf. this JOURNAL 10, p. 466).

In the leaf-cell of *Selaginella uncinata*, *S. kraussiana* and *Adiantum capillus-veneris* the chloroplast forms the network, which is clearly visible after proper fixation and staining. In the leaf-cell of *Adiantum capillus-veneris* and the prothallium-cell of *Pteris multifida* the chloroplast stains homogeneously, when it contains starch grains, as it is usual. Sometimes, however, it stains partly homogeneously and partly shows the grana structure. In the stem cell of *Selaginella uncinata*, when the chloroplast is changing into the leucoplast, the network disappears, and diffuses in the ground substance.

The leucoplast in the rhizophore of *Selaginella uncinata* shows various figures according to the difference of fixing agents, thus, for example, network, two parallel bars, amorphous, vacuolate, unstainable, horse-shoe-shaped, etc.

A very thin membrane envelops the chloroplast, and it is recognizable by staining with HEIDENHAIN's iron haematoxylin materials fixed by various agents.

**272. Pyrenoid division in *Prasiola japonica*.** (Japanese). Akira YUASA. (B.M.T. 54, 1940, 196-198, 2 text-figs.-groups).

Each living cell of the thallus of *Prasiola japonica* shows a star-shaped chromatophore. In the centre of the latter one opaque, intensely light-refracting spherical body is recognizable, i.e. pyrenoid, which is stainable by acetocarmine or intensely so by haematoxylin. Its bipartition in various stages was seen and is illustrated in this paper.





ERRATA in Vol. XI, No. 2

	<i>read</i>	<i>instead of</i>
p. (66), line 23 from below	<i>Capsicum</i>	<i>Cupsicum</i>
p. (71), line 17 from below	12	112

